Regional Wastewater Services Plan
WATER QUALITY REPORT

March 2005

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King County
Department of
Natural Resources and Parks
Wastewater Treatment Division

Regional Wastewater Services Plan

RWSP Water Quality Report

March 2005

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Department of Natural Resources and Parks
Wastewater Treatment Division

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2005 RWSP WQ Report

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Executive Summary

This report describes the efforts of King County's Department of Natural Resources and Parks (DNRP) in 2004 to protect and preserve water quality in Puget Sound and the major lakes and rivers in the county. It focuses on waters that benefit from or that could be impacted by the operations of King County's wastewater treatment and conveyance system. These operations include wastewater management, wastewater discharges, sanitary sewer overflows (untreated wastewater), and combined sewer overflows (untreated wastewater combined with stormwater runoff).

This report is required by King County Ordinance 13680, which adopted the Regional Wastewater Services Plan (RWSP)—a $1.85 billion[1] capital improvement program to provide wastewater capacity for this region for the next 30 years and beyond. Ordinance 13680 identified the need for an annual water quality report:

> [To] ensure that the RWSP reflects current conditions and addresses water pollution abatement, water quality monitoring results, water conservation and water reclamation, Endangered Species Act compliance, septic system conversions to the regional sewer system, biosolids management, wastewater public health problems, and compliance with other agency regulations and agreements.

This Executive Summary provides an overview of the information provided in the report, beginning with a summary of the state of waters in King County and continuing with a description of the County's programs to manage and monitor the quality of its waters.

State of the Waters

Three major groups of waters are described in this report: the major lakes, including Lake Washington, Lake Sammamish, and Lake Union; the rivers and streams, including the Cedar River, the Sammamish River, and the Green River, and the Duwamish River; and the marine waters of Puget Sound. These waters are shown in Figure 1-1 (in Chapter 1) and their status is summarized below.

Major Lakes

Water quality in the major lakes, as described by their biological productivity, has ranged between moderate to exceptionally good during the last several years. Historically, excess phosphorous loading was a problem in both Lake Washington and Lake Sammamish, resulting in nuisance algal blooms in the summer. Lake Washington had good water quality in 2004, with good water clarity and low concentrations of algae. Water quality was moderate in Lake

[1] In 2004 dollars.

Sammamish, with good water clarity, moderate concentrations of algae, and moderate concentrations of phosphorous. Since 1998, phosphorous concentrations in Lake Sammamish have been well below the goal of 22 µg/L (mean annual volume weighted total phosphorous) as defined in the 1989 *Lake Sammamish Management Plan.* In 2004, the mean phosphorus concentration (23 µg/L) was slightly higher than the goal. Although their water quality was good or moderate, Lakes Washington and Sammamish remain vulnerable to water quality degradation by urbanization and land use activities such as construction, development, forestry, and farming. Lake Union's water quality was moderate in 2004 and has fluctuated between moderate and good since 1994.

Rivers and Streams

Water quality in the Cedar River is typically very high. The river was listed on the Washington State Department of Ecology's 1998 303(d) list[2] for exceeding the fecal coliform standard, as do many other state waters. Much of the Cedar River watershed is forested, which is the major contributor to the continued high water quality in the river. Diversion of flows from the river for drinking water is a major issue for the Cedar River. In 2004, its water quality was considered in the moderate-concern range.

The Sammamish River is listed on the 1998 303(d) list for exceeding standards for temperature, dissolved oxygen, pH, and fecal coliform. High river temperatures typically occur in the summer and early fall when chinook and sockeye salmon are returning to spawn in tributaries. In general, elevated temperature and low dissolved oxygen are considered serious water quality problems that limit salmonid survival in the river. In 2004, Sammamish River water quality was considered in the moderate- to high-concern range, depending on sampling location.

Water quality in the Green River and its tributaries varies widely depending on location in the watershed, level of urbanization, and human activities. Numerous streams throughout the Green-Duwamish watershed are listed on the 303(d) list, including portions of the Duwamish River and lower Green River. Low dissolved oxygen, high temperature, and high fecal coliform bacteria levels are concerns in the Green River watershed, and there has been a trend toward increasing water temperatures in tributaries in the urbanized part of the watershed. Sediment contamination is a significant focus of attention in the Lower Duwamish River.

Puget Sound

The marine waters of Puget Sound within King County are in very good condition overall and do not show evidence of persistent bacterial, nutrient, or toxicant pollution. Offshore waters have consistently shown high levels of dissolved oxygen and low fecal coliform bacteria over the last several years. There were some pollution problems in the nearshore environment, however, with localized areas failing Water Quality Standards for fecal coliform bacteria—particularly in areas

[2] The 303(d) list identifies water bodies that do not meet State Water Quality Standards.

near freshwater sources or in areas of poor tidal flushing. Another localized problem is sediment contamination, which is evident primarily in Elliott Bay.

Water Quality Management Programs

King County has many programs in place that protect and preserve water quality. The wastewater treatment system collects wastewater from 34 cities and sewer districts serving approximately 1.4 million residents and conveys it to a local plant on Vashon Island, and to two regional treatment plants: the West Point Treatment Plant in Seattle and the South Treatment Plant in Renton. On average, these plants provide secondary treatment for over 183 million gallons of wastewater each day. The quality of treated effluent from these plants remained high in 2004 with effluent values typically much higher in quality than what is required by wastewater discharge permits.

King County also has a program to reduce the amount of combined sewer overflows (CSOs), with two large CSO projects under way: Denny Way/Lake Union and Henderson/Martin Luther King/Norfolk. As part of the RWSP, the County has committed to controlling all its CSO discharge locations to no more than one untreated discharge per year by 2030, as required by Washington State regulation.

In addition, two source control programs are working to prevent pollutants from even reaching our treatment plants and the environment—the Industrial Waste Program and the Local Hazardous Waste Management Program. For example, last year the Industrial Waste Program, which regulates industrial wastewater discharges, collected 2,104 samples and found 54 violations of discharge regulations. All violations were followed up with some form of enforcement action.

The County also recovers its resources where possible, recycling 100 percent of its biosolids from the wastewater treatment process, implementing a program that provides reclaimed water for use in treatment plant operations and for customers in the service area, and recovering methane (digester gas) for use in running plant operations. Construction of the innovative 1-megawatt fuel cell project at South Treatment Plant was completed and began a two-year demonstration period in April 2004. If the demonstration is successful, the facility will be used on an ongoing basis to produce electricity from methane.

Monitoring the Health of King County Waters

To protect public health and its significant investment in water quality improvements, King County regularly monitors its major lakes, beaches, streams, marine waters, and wastewater effluent. The major lakes monitoring program collects samples from 5 sites in Lake Union, 13 sites in Lake Washington, and 7 sites in Lake Sammamish. Sampled parameters include temperature, dissolved oxygen, pH, conductivity, clarity (Secchi Transparency), phosphorus, nitrogen, and fecal coliform bacteria.

The swimming beach monitoring program assesses beaches on Lake Sammamish, Lake Washington, and Green Lake every summer. This effort, ongoing since 1996, tests for bacteria to determine if there are risks to human health.

The stream monitoring program targets locations in streams and rivers where they cross sewer trunk lines or if they are considered a potential source of pollutant loading to a major water body. The long-term program has sampled at fifty-four sites on 4 rivers and 28 streams for many years.

King County's marine monitoring program routinely evaluates nutrient, bacteria, and dissolved oxygen levels in the waters of the main basin of Puget Sound. The program also includes monitoring of sediment quality near outfalls and at ambient locations. The goals of the ambient monitoring program are to better understand regional water quality and to provide data needed to identify trends that might show impacts from long-term cumulative pollution.

In addition, the County conducts special intensive investigations of water quality to support specific decision-making. Currently two watershed studies are under way to understand water quality issues and needs, to project future growth impacts in County watersheds, and to identify any needed improvements to salmon habitat. Several studies are under way to support decision-making, siting, and construction of wastewater management facilities.

King County regularly monitors its wastewater effluent using process laboratories at both of its regional treatment plants and the environmental laboratory in Seattle.

2004 Results

Management and monitoring program performance in 2004 indicates that County efforts continue to make a significant contribution to protecting regional water quality and protecting public health. No needs were identified that are not already being addressed, and the wastewater system is achieving its purposes. Continuing vigilance by agencies like King County is recommended as the pressures of urbanization on water quality continue to increase. King County residents will then continue to enjoy the excellent water quality that they value and expect.

Chapter 1

Introduction

This chapter provides background on King County's wastewater management history, including its water quality monitoring programs. It then gives the purpose of this water quality report and describes the water bodies in the county that are included in these programs.

Background

In 1911, the City of Seattle completed construction of the Fort Lawton Tunnel. The purpose of the tunnel was to discharge untreated wastewater flows off West Point (what is now Discovery Park) into Puget Sound. Early wastewater systems, which were the beginning of the current combined sewerage system in the City of Seattle, were built to collect wastewater from homes and businesses and stormwater runoff from streets.

By the 1950s, more than 25 small wastewater treatment plants were operating in the Seattle metropolitan area. But not all communities were served by treatment plants. Untreated wastewater entered Lake Washington, Lake Sammamish, Elliott Bay, the Duwamish River, the Lake Washington Ship Canal, and Puget Sound. About 40 million gallons of untreated wastewater was discharged off of Discovery Park alone each day.

The degradation of water quality in Lake Washington resulted in beach closures. Citizens voiced concern about the future of Lake Washington and other local waters. A grassroots citizens committee was formed that successfully sponsored state legislation allowing formation of a municipal corporation to manage the wastewater pollution problem for the Seattle metropolitan area. As a result, the Municipality of Metropolitan Seattle (Metro) was formed in 1958 to assume responsibility for cleaning up Lake Washington and establishing a regional wastewater system.

Metro developed the *Comprehensive Sewerage Plan* that became the guiding planning document for wastewater treatment services in the Lake Washington drainage basin for the next 35 years. Under that plan, Metro built regional treatment plants, closed small plants, constructed major trunk lines and pump stations to move the wastewater to the new plants, and eliminated 46 untreated wastewater discharge points into Lake Washington and Lake Sammamish. The plan has been amended periodically; the *1999 Regional Wastewater Services Plan* (RWSP) is the most recent significant amendment.

By the 1960s, Lake Washington's water quality had dramatically improved. The King County area became known as a national model of citizen action in cleaning up the environment. Metropolitan King County assumed Metro's functions in 1994. With the combined King County and Metro resources and expertise, the County became a regional provider of water quality protection services.

In addition to providing wastewater management services, King County performs many other activities to protect and improve water quality. These activities include monitoring water quality in lakes and streams, educating the public about water quality issues, and providing grant funds for local water quality projects. Water quality sampling and monitoring efforts began in 1962 to track cleanup progress in Lake Washington and to measure the impacts of diverting wastewater effluent from the lake to deep-water outfalls in Puget Sound. Monitoring programs and scientific studies have since remained a key element in the County's wastewater management program, providing the necessary data to inform decisions on wastewater service and water quality management activities and to evaluate the effectiveness of those actions.

Purpose of this Report

The RWSP, King County's most recent comprehensive sewerage plan amendment, is a $1.85 billion (in 2004 dollars) capital improvement program to provide wastewater capacity for the region for the next 30 years and beyond. The plan includes the following elements:

- Siting and construction of a new regional treatment plant in the north County service area
- Construction of new conveyance lines and pump stations
- Implementation of 22 projects to complete combined sewer overflow (CSO) control
- Implementation of programs to investigate control of inflow and infiltration of clean water into the County system, water reuse, and technologies to manage treatment plant solids

To provide the flexibility to adapt to changing conditions and needs, Ordinance 13680 (1999) adopting the RWSP requires a comprehensive review and update of the RWSP every three years. The first update to the RWSP was published in 2004. The ordinance also requires the development of an annual water quality report. The purpose of the report, as stated in the ordinance, is as follows:

> [To] ensure that the RWSP reflects current conditions and addresses water pollution abatement, water quality monitoring results, water conservation and water reclamation, Endangered Species Act compliance, septic system conversions to the regional sewer system, biosolids management, wastewater public health problems, and compliance with other agency regulations and agreements.

The *2005 RWSP Water Quality Report* meets this requirement. This report describes the scientific and institutional programs that support implementation of the RWSP and presents the results of activities conducted in 2004 in the course of implementing these programs.

The remainder of this chapter describes the water bodies in King County. The chapters that follow describe County programs to manage and monitor water quality in the region; present the state of the waters in 2004; and outline continuing issues and needs concerning the health of county waters. A glossary of technical terms and a list of relevant Web sites are appended to the report.

King County Waters

King County's wastewater service area includes major freshwater streams and lakes and the marine waters of Puget Sound. The fresh waters are grouped into watersheds designated as Water Resource Inventory Areas (WRIAs). The State of Washington established WRIAs to help manage resources within each watershed. The Cedar-Sammamish watershed (WRIA 08) and the Green-Duwamish watershed (WRIA 09) make up the majority of the County's wastewater service area. Figure 1-1 shows the boundaries and the major water bodies of these two WRIAs.

Cedar-Sammamish Watershed (WRIA 08)

Approximately 85 percent of the Cedar-Sammamish watershed lies within King County; the remaining 15 percent is in Snohomish County. The eastern portion of the watershed lies in the Cascade Range, and the western portion occupies the Puget Sound lowland. The major lakes in WRIA 08 studied by King County are Lake Sammamish, Lake Washington, and Lake Union.

The Cedar-Sammamish watershed has been dramatically altered in the last 150 years, primarily the result of the following activities:

- Building of the Landsburg Diversion Dam at the turn of the century by the City of Seattle to tap into the Cedar River as the City's main source of water
- Construction of the Lake Washington Ship Canal and Hiram M. Chittendon Locks between 1910 and 1920, which redirected the outlet of Lake Washington from its south end at the Black River to the north through Lake Union and the Locks
- Dropping of Lake Washington's level by almost 9 feet as the result construction of the Ship Canal and Locks
- Dropping of the level of Lake Sammamish as a result of the change in the level of Lake Washington
- Draining of the wetlands along much of the shoreline of Lakes Washington and Sammamish as a result of their level changes
- Channelization of the Sammamish River in the early 1920s

Lake Washington

Lake Washington is the largest of the three major lakes in King County and the second largest natural lake in the State of Washington. The lake is 21,500 acres in area, 13 miles long, and 108 feet at its deepest point. Some of the beneficial uses of Lake Washington include fish rearing, spawning, and harvesting; wildlife habitat; swimming; and boating. Lake Washington is the prime rearing habitat for juvenile salmon spawned in the Cedar and Sammamish Rivers and supports a number of resident fisheries.

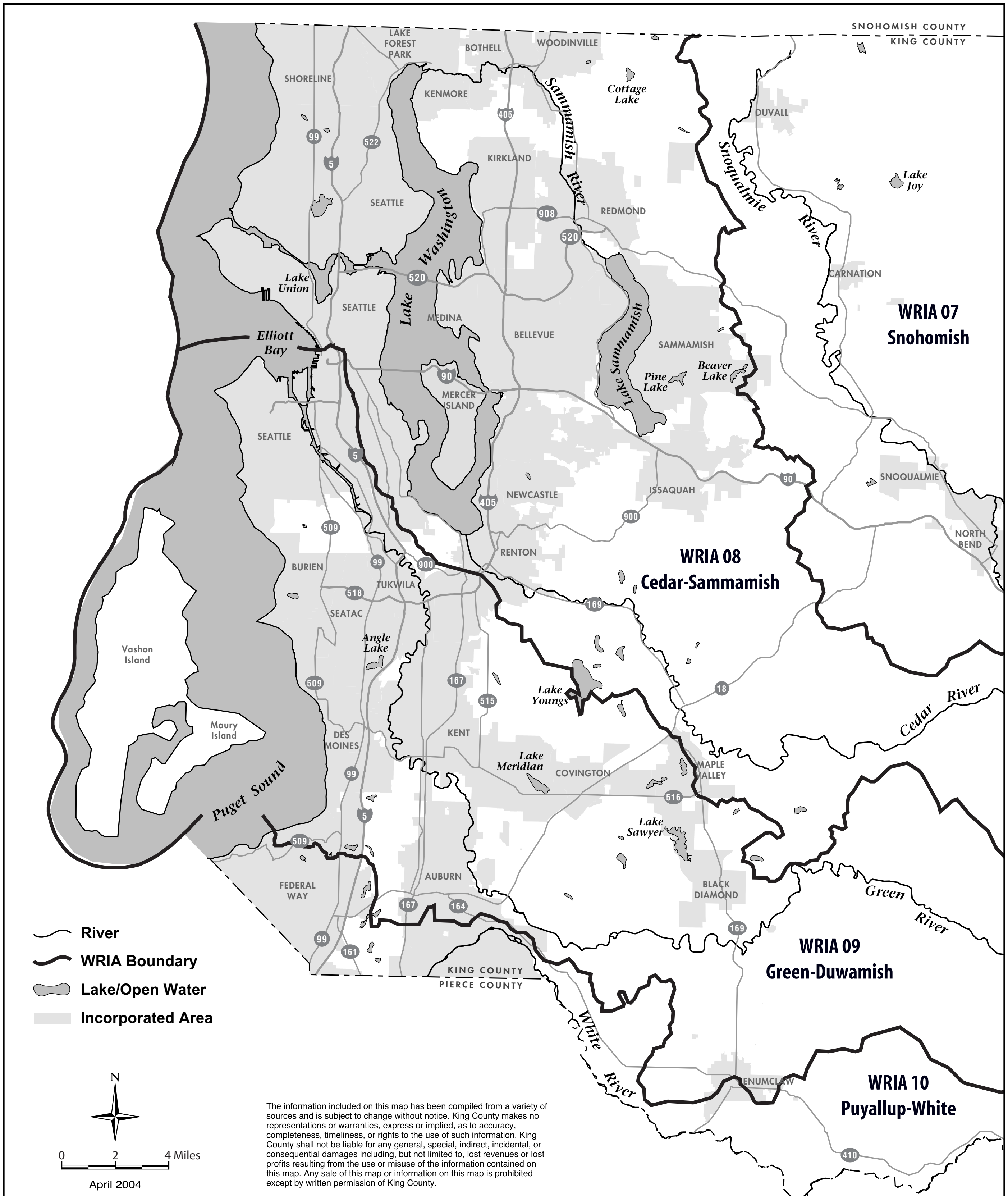

Figure 1-1
Major Water Bodies in King County WRIAs

King County
Department of
Natural Resources and Parks
Wastewater Treatment Division

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By the late 1960s, all wastewater discharge to both Lake Washington and Lake Sammamish ceased, eliminating about 75 percent of the nutrient inputs to the lakes. The subsequent water quality improvements were dramatic. Now phosphorus concentrations in Lake Washington are in large part a reflection of the amount of phosphorus entering the lake from nearshore runoff and the Cedar and Sammamish Rivers. The Cedar river contributes about 57 percent of the water to the lake but only 25 percent of the phosphorus, whereas the Sammamish River contributes 27 percent of the water and 41 percent of the phosphorus.

Lake Sammamish

Lake Sammamish is the sixth largest lake in Washington and the second largest lake in King County. Some of the beneficial uses of the lake include fishing, boating, swimming, water skiing, and picnicking. The lake also provides rearing and migratory habitat for multiple salmon species and is home to a variety of warm-water fish, birds, and other wildlife. The beneficial uses of water bodies in the Sammamish basin include fish rearing, spawning, and harvesting; wildlife habitat; swimming (primary contact recreation); and boating (secondary contact recreation).

Lake Sammamish has historically suffered from excess phosphorus loading, with frequent late summer algal blooms and a dominance of the aquatic plant Eurasian milfoil (*Myriophylum spicatum*). Over the five-year period following the cessation of wastewater discharges in the late 1960s, water quality responded favorably showing a 50 percent reduction of phosphorus and algal concentrations and a 35 percent increase in water clarity. In an effort to maintain this improved water quality in the face of the increasing development that is occurring in this basin, a citizen's task force, Partners For a Clean Lake Sammamish, worked to complete the 1996 *Lake Sammamish Water Quality Management Plan.* The plan assumes that control of the amount of phosphorus entering the lake would affect levels of algal blooms, water clarity, and dissolved oxygen. Measures to control phosphorus loading to the lake also provide secondary benefits to the watershed, including control of erosion and sedimentation and preservation of fish habitat, forest cover, and riparian cover.

Lake Union

Lake Union is 580 acres in area and averages 34 feet deep. This lake differs significantly from the other two major lakes in the county. Its hydrology was modified when the Lake Washington Ship Canal and the Hiram M. Chittenden Locks were constructed early in the twentieth century to connect Lake Washington with Puget Sound. This construction allowed intrusion of salt water into Lake Union. The intrusion produced strongly stratified lake conditions. The more dense saline bottom water becomes devoid of oxygen early in the summer as bacteria thrive in the organically rich sediments at the bottom of the lake, limiting the amount of habitat available to fish. The lake and canal systems are the only migration route for the salmonids in the Lake Washington, Cedar River, and Lake Sammamish drainages.

In the past, untreated wastewater entered Lake Union from local wastewater collection systems and from houseboats, ships, industries, and businesses along its shore. Other sources of pollution, including fuel spills, contributed to impacts on Lake Union's water quality. Pollution inputs from many of these sources have decreased. Untreated wastewater was intercepted for treatment in the 1980s, and the remaining CSOs are being controlled. In 1994, a CSO separation project in the University Regulator basin removed a significant amount of CSOs from the lake. The project included construction of a new stormwater outfall. A study to assess the impact of the stormwater discharge from the outfall found that there were no adverse impacts. In fact, sediment quality and the benthic community improved. A joint project between King County and the City of Seattle—the Denny Way/Lake Union CSO control project—is currently in construction and will be completed in 2005. The project will control all CSOs that discharge directly into Lake Union. Remaining CSOs along the Ship Canal will be controlled as part of the County's RWSP (1999) and the City of Seattle's *Combined Sewer Overflow Control Plan Amendment* (2001).

Sammamish River

Long, straight, and open describes the Sammamish River, which since the late 1800s has been dredged, realigned, and stripped of much of its forest cover. The river was channeled and dredged in the early 1960s for flood control and land use. Existing native vegetation was also removed from its banks, although recent recovery efforts are beginning to improve the condition of the riparian area. Generally, conditions in the Sammamish River are fair compared to the State Water Quality Standards and, as in most streams and rivers, water quality seems to be better in the upper reaches where development is minimal. The Bear-Evans Creek system, one of the major salmon producing streams in King County, drains into the Sammamish River. However, the river continues to experience degraded fish habitat and increased flooding and erosion from ongoing development that began in the 1970s and 1980s.

Cedar River

The Cedar River is the largest tributary to Lake Washington and drains nearly 200 square miles from the crest of the Cascade Range to Lake Washington at the City of Renton. The upper two-thirds of the basin is owned and managed by the City of Seattle and supplies drinking water to two-thirds of Seattle and its regional customers. The upper watershed is closed to the public and is managed under the *Cedar River Habitat Conservation Plan* (Seattle Public Utilities, 1999). The lower portion of the river is primarily forested or rural, except near the mouth where the river passes through the City of Renton.

Small Streams

The Cedar-Sammamish watershed contains many small streams. Twenty-two streams are in areas near wastewater facilities or are considered potential sources of pollution to their downstream water bodies. These streams are Bear-Evans, Coal, Ebright, Eden, Fairweather, Forbes, Idlewood, Issaquah, Juanita, Kelsey, Lewis, Little Bear, Longfellow, Lyon, May, McAleer, North, Pine, Swamp, Thornton, Tibbets, and Yarrow Creeks.

Green-Duwamish Watershed (WRIA 09)

The Green-Duwamish watershed begins in the Cascade Range about 30 miles northeast of Mount Rainier and flows for over 93 miles to Puget Sound at Elliott Bay in Seattle. Historically, the White, Green, and Cedar (via the Black) Rivers flowed into the Duwamish River, draining an area of over 1,600 square miles. The Green-Duwamish River watershed is now one of the most altered hydrological ecosystems in the Puget Sound basin. To date, 98 percent of the Duwamish estuary has been filled, 70 percent of the flows have been diverted out of the basin, and about 90 percent of the once extensive floodplain is no longer flooded on a regular basis. The watershed now drains only 556 square miles. The following activities brought about these changes:

- Dredging, channelizing, and diking of the Duwamish River for navigation and flood control between 1895 and 1980
- Filling and draining of the estuary tidelands to support industry and port activities between 1900 and 1940
- Diversion of the White River from the Green River to the Puyallup River for flood control in 1911
- Diversion by the City of Tacoma of water from the Green River system for drinking water supply in 1913
- Diversion of the Black and Cedar Rivers from the Duwamish River to Lake Washington in 1916
- Construction of the Howard Hanson Dam near the headwaters of the Green River for flood control in 1962

King County’s wastewater service area includes the Green River, Duwamish River, and several small streams. There are no major lakes in the Green-Duwamish watershed.

Green River

The lower Green River and its valley are urbanized, consisting of dense commercial and industrial development as well as some of the fastest growing suburban communities in King County. Most of this area is incorporated, including the Cities of Seattle, Tukwila, Renton, Kent, and Auburn. Much of the commercial and residential development in the valley depends on a levee and dike system to contain the river. The middle Green River watershed includes rich farmlands and forests. This area also includes the cities of Covington, Maple Valley, Black Diamond, and Enumclaw; several state and county parks; and a salmon hatchery. The area is increasingly important as an affordable area for suburban and rural residences and hobby farms, is one of the largest remaining agricultural communities in King County, and provides extensive recreational opportunities for residents. The upper Green River extends from its headwaters at the crest of the Cascade Range to the the Howard Hanson Dam diversion dam. The dam provides drinking water to the City of Tacoma and water for forest production for federal, state, and private landowners.

Duwamish River

The Duwamish River provides a passageway to the inland portions of the state. The area around the river is heavily urbanized, consisting of dense commercial and industrial development. Concrete, glass, steel, and lumber factories and construction and barge companies have all been a part of its economic fabric.

Small Streams

Five small streams in this watershed occur in areas near wastewater facilities or are considered potential sources of pollution to their downstream water bodies. These streams are Crisp, Mill, Newaukum, Soos, and Springbrook Creeks.

Puget Sound Marine Waters

Puget Sound is the southernmost of a series of glacially scoured channels that are relatively protected by a single entrance 84 miles from the Pacific Ocean. The Sound is a large estuary where fresh water draining from more than 10,000 streams and rivers mixes with salt water entering from the Pacific Ocean through Admiralty Inlet and Deception Pass. It is surrounded by 2,354 miles of shoreline, including beaches, bluffs, mudflats, deltas, and wetlands.

Puget Sound consists of four major basins: the Main (Admiralty Inlet and the Central Basin), Whidbey, Southern, and Hood Canal Basins. Each basin exhibits different characteristics depending on its water circulation and underwater topography. The average depth is 348 feet. The Main Basin has depths greater than 920 feet and is shielded at the main entrance to the Sound by the Admiralty Inlet sill that impedes the exchange of deep waters.

Mechanisms at work in Puget Sound help to produce favorable water quality conditions. This water body maintains near-oceanic salinity throughout most of the year and is supplemented with cold, nutrient-rich, low-oxygenated deep water upwelling off the Washington coast during the late summer and fall months. This upwelling creates a partially mixed two-layer system, with relatively fresh water flowing seaward at the surface and saline oceanic water returning landward at depth. The Sound has a mixed, semi-diurnal tidal cycle that is characterized by two unequal high tides and two unequal low tides each day with an average tidal exchange of 12 to 14 feet. Half of its water can be replaced with fresh ocean water in a tidal cycle.

Chapter 2

Water Quality Management Programs

This chapter describes King County's water quality management programs, including its regional wastewater system and its programs for controlling pollutants at their source, for cleaning up contaminated sediments near combined sewer overflow outfalls, and for recovering resources.

Regional Wastewater System

The King County wastewater system serves approximately 1.4 million residents in a 420-square-mile service area. A total of 275 miles of pipes, 42 pump stations, and 19 regulator stations move wastewater from homes and businesses served by local agencies to two large regional treatment plants—the West Point Treatment Plant in Seattle and the South Treatment Plant in Renton—and a small treatment plant on Vashon Island (Figure 2-1). These three plants treat wastewater to the secondary level. In addition, King County operates two combined sewer overflow (CSO) treatment plants at Alki and Carkeek Park in Seattle. The Alki and Carkeek plants provide primary treatment of excess flows that occur in the combined sewer system during storm events.

Secondary Treatment Plants

The federal Clean Water Act states that all wastewater collection and treatment facilities that discharge effluent into surface waters are required to have a National Pollutant Discharge Elimination System (NPDES) permit. NPDES permits are issued by the Washington State Department of Ecology (Ecology) and set limits on the quality of effluent discharged from point sources such as treatment plants and industrial facilities. King County holds NPDES permits for its West Point, South, and Vashon Treatment Plants. The West Point NPDES permit also includes the Alki and Carkeek CSO plants and the CSO outfalls.

The treatment process is an intensive and controlled version of the biodegradation of organic material that occurs in the natural world. Wastewater coming into the plants undergoes a series of treatment processes. The first is preliminary treatment, which screens out large items such as sticks, cans, and rags and then settles out heavy suspended material such as sand and grit. The next process is primary treatment. Here, wastewater flows through large settling tanks (primary sedimentation tanks) that allow up to 60 percent of suspended material to settle out. This treated water, called primary effluent, is then directed to the secondary aeration tanks.

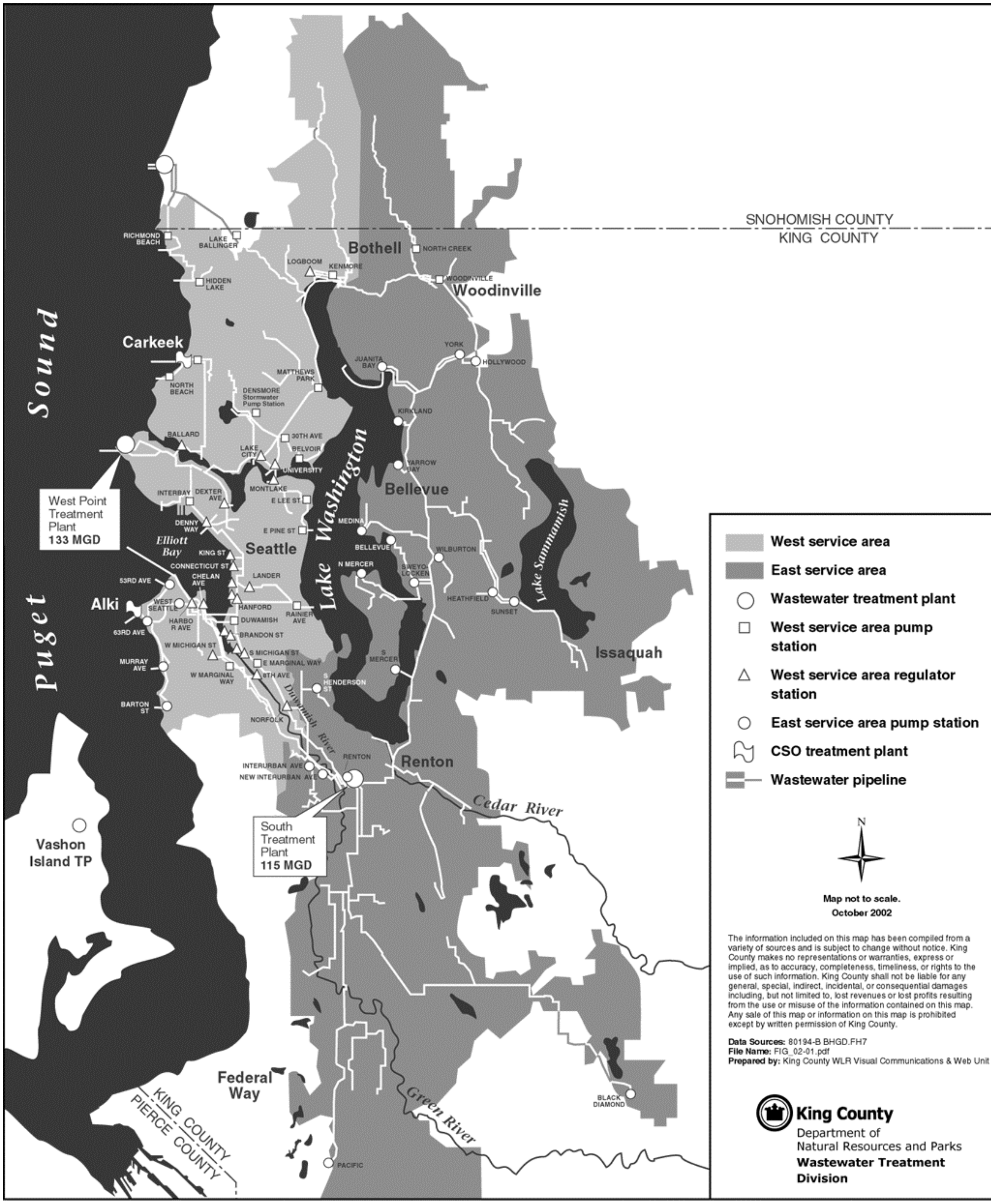

Figure 2-1. King County Regional Wastewater System

Unlike primary treatment, which relies on settling to remove coarse suspended material, secondary treatment uses aerobic bacteria to consume and digest the fine organic material in solution. The bacteria are called "aerobic" because they need air to survive. In the secondary treatment process, oxygen is bubbled into large aeration tanks where bacteria consume the dissolved organic material. After time, this mix of bacteria and primary effluent moves into large tanks (secondary clarifiers) that allow the bacteria and other fine material to settle out, removing 90 percent or more of pollutants. This highly treated water, called secondary effluent, is disinfected with chlorine, sometimes dechlorinated, and then pumped to an outfall that diffuses it deep in Puget Sound.

Solids are generated at each point in the treatment process. The heavier sand and grit collected from preliminary treatment are disposed of in a landfill. Solids collected from the primary sedimentation tanks and secondary clarifiers (termed sludge) are thickened by a dewatering process to 10 to 20 percent of their original volume and conveyed to large aboveground digesters. Here, anaerobic bacteria (bacteria that need no oxygen) digest the sludge for three to four weeks, producing a byproduct called biosolids—a nutrient-rich organic material used as compost or fertilizer in agriculture and forestry.

Both the West Point and South Treatment Plants also produce reclaimed water, which is secondary effluent that receives additional treatment using sand filters or other processes to produce non-potable water for irrigation, industrial processes, and treatment plant systems.

South Treatment Plant

The South Treatment Plant, located on Monster Road in Renton, treats wastewater flows from customers in the lower Green River basin, suburban cities east of Lake Washington, and Seattle's Rainier Valley. The plant provides secondary treatment of wastewater and treats about 20 million gallons (MG) per year of septic tank solids from throughout the region as well as sludge from treatment facilities in neighboring areas such as Snoqualmie Valley cities and Vashon Island. The South Treatment Plant is current holder of an Association of Metropolitan Sewerage Agencies (AMSA) Platinum Award for excellent operation.

The South Treatment Plant is designed to manage a monthly wet-weather average flow of 115 million gallons per day (mgd). The effluent pumping capacity at the South Treatment Plant was recently upgraded to handle a peak flow of 325 mgd. The outfall in Puget Sound discharges secondary effluent 10,000 feet from shore at a depth of 600 feet into the denser deeper water layer. The increasingly diluted effluent plume moves southward in the Sound, remaining at or below a depth of 390 feet.

West Point Treatment Plant

The West Point Treatment Plant, located on the shore of Puget Sound in Discovery Park, provides secondary treatment for wastewater from customers located in the greater Seattle area and in southwest Snohomish County. It is the largest plant in the King County system, designed to manage an average wet-weather, non-storm flow of 133 mgd and a peak wet-weather flow of 440 mgd. After treatment, the secondary effluent is discharged through an outfall to Puget

Sound. The outfall discharges 3,650 feet from shore at a depth of 240 feet. The increasingly dilute effluent plume flows northward most of the year, out of Puget Sound. The West Point plant is current holder of the AMSA Gold Award for excellent operation.

The plant is designed to provide secondary treatment for up to 300 mgd. Capacity between the 300-mgd capacity for secondary treatment and the 440-mgd peak capacity of the plant is used to manage captured CSO. The plant provides these CSO flows with primary treatment, disinfection, and dechlorination.

Vashon Treatment Plant

The Vashon Treatment Plant is located northeast of the unincorporated Town of Vashon, on the east side of the Vashon Island. This secondary treatment plant was constructed in 1975 and operated by the Vashon Sewer District until 1999, when King County assumed responsibility for the plant. The plant was designed to manage a monthly average flow of 0.264 mgd and a peak flow of approximately 1.0 mgd. After secondary treatment and disinfection, the effluent was discharged through an outfall to Puget Sound. The outfall discharged 1,300 feet offshore at a depth of -41 feet mean lower low water (MLLW).

The treatment plant had a history of frequent NPDES violations. Since King County assumed responsibility for plant operations and facilities, many improvements have been made to allow the plant to operate more consistently with far fewer violations. Improvements included removal of hydraulic restrictions in the outfall line to increase its peak-flow handling capacity, addition of a new ultraviolet disinfection process, improvement of sludge handling processes, and enhancement of the electrical and water utilities.

In addition, to ensure that all permit limits will be met in the future, construction began in autumn 2004 on a new higher-capacity treatment facility. Along with higher capacity, the new facility will add backup systems and extend the outfall further out into Puget Sound. Extension of the outfall was completed in November 2004. The outfall now extends an additional 1,450 feet into Puget Sound where it discharges at a depth of -200 feet MLLW. Construction is expected to be completed on the treatment facility by 2006.

Treatment Plant Flows and NPDES Compliance in 2004

King County’s facilities continue to be in compliance with the terms and conditions of its NPDES permits, and so are in compliance with the Washington State Water Pollution Control Law, the Federal Water Pollution Control Act, and the Federal Clean Water Act.

Despite the fluctuation of flow and influent composition, South Treatment Plant’s secondary treatment process consistently produces high quality secondary effluent. In 2004, the plant managed an average flow of 68 mgd with a maximum daily average flow of about 172 mgd. Treatment efficiency remained high and consistent. The plant experienced two exceptions to the Class A reclaimed water permit limits. The reclaimed water exceptions resulted from higher-than-permitted fecal coliform counts that stopped the distribution of reclaimed water for a short time. At one other time, disinfection of reclaimed water was interrupted for 15 minutes. This interruption did not result in a permit exception.

The average flow in 2004 through the West Point Treatment Plant was about 100 mgd with a maximum daily average flow of 200 mgd. No permit limit violations occurred in 2004. There were two episodes when a small volume of flow was diverted around secondary treatment because of mechanical problems. The flow was blended with fully treated effluent; the discharged effluent stayed within permit limitations.

At the Vashon plant, the average flow in 2004 was 0.11 mgd with a maximum daily average flow of 0.18 mgd. There were no NPDES permit exceptions in 2004.

The renewed West Point permit was issued in late December 2003 and became effective January 1, 2004. Negotiations were completed in September 2004 for the renewal of the South Treatment Plant permit. The permit was issued and became effective on October 1, 2004. The renewed permit differs from the previous permit (July 1997 through September 2004) for South Treatment Plant in the following ways:

- Minor changes to mixing zone boundaries
- Minor changes to chlorine limits
- Minor changes to laboratory testing requirements and monitoring frequencies of some sampling
- Changes to Green River emergency and maintenance discharge limits and requirements
- Increase in frequency in reporting on inflow and infiltration program and plant waste load assessments
- New requirements for reporting on blending events
- Removal of requirement for outfall sediment testing
- New reporting requirement on review of operation and maintenance manuals

Sanitary Sewer Overflows

Sanitary sewer overflows (SSOs) are discharges of wastewater from separated sewer systems and also from combined systems when no rain is occurring. SSOs can flow from manholes, broken pipes, or pump stations onto city streets, into water bodies, and even as backups into basements. SSOs occur on rare occasions, typically during extreme storm events and power outages. Minimizing the discharge of untreated wastewater is fundamental to the mission of the Wastewater Treatment Division, and extensive resources have been committed to maintaining the integrity of the system and preventing SSOs. The County’s Maintenance and Asset Management groups maintain a regular schedule of inspection, maintenance, and repair of facilities to prevent mechanical failures and SSOs.

Sanitary Sewer Overflow Activity in 2004

Table 2-1 shows that King County reported eight SSOs in 2004, which is below the annual average of 15 (based on averages over a 15-year period). Four of the SSOs flowed into Puget Sound (two into Elliott Bay), one into the Duwamish River, one into the Green River, and one into the White River. One overflow was contained before reaching any water body. The overflows ranged in size from 643 to 420,000 gallons. While there is some short-term risk to public health and the environment from SSOs, there are no long-term effects from this volume of release. In all cases, the County's overflow response procedures were implemented. These procedures include posting the area, sampling, and public notification as appropriate for the nature of the overflow.

Table 2-1. Sanitary Sewer Overflows in 2004

Date	Location	Estimated Volume (gallons)	Duration (hours)	Discharge Type	Receiving Waters	Reason for Overflow
Jan. 7	Pacific Pump Station	42,000	2.5	Untreated wastewater	White River	Storm-related loss of power
Jan. 23	Michegan Regulator	250,000	1	Untreated wastewater	Duwamish River	Maintenance error (incorrect gate setting)
April 14	Fort Dent Park	5,000–10,000	1.5	Reclaimed water	Green River	Leakage from reclaimed water distribution line
April 23	West Point Treatment Plant	420,000	0.1	Partially treated wastewater	Puget Sound[a]	Mechanical failure in treatment plant gate
July 12	Harbor Regulator	111,000	3.5	Untreated wastewater	Elliott Bay	Operator error
July 28	Harbor Regulator	123,500	2.25	Untreated wastewater	Elliott Bay	Operator error
Oct. 24	Barton Pump Station	9,100	0.25	Untreated wastewater	Puget Sound	Power outage
Nov. 1	Sweyolocken Pump Station	643	0.017	Untreated wastewater	No water body (or possibly Mercer Slough)	Mechanical failure

[a] No additional discharge occurred. The volume bypassed secondary treatment and was merged with plant effluent before being discharged.

Combined Sewer Overflows

The combined sewer system carries both wastewater and stormwater. The City of Seattle is the only wastewater agency served by King County that has such a system. This combined system is primarily in the West Point service area. The other local collection systems are separated sewer systems. In separated systems, some pipes carry wastewater to large King County pipelines while other pipes carry stormwater to the nearest water body. Figure 2-2 and Figure 2-3 illustrate combined and separated sewer systems.

During periods of heavy rainfall when flows exceed the capacity of the conveyance system or the secondary and CSO treatment plants, untreated discharges of wastewater and stormwater from combined sewers are released via outfalls directly into marine waters, lakes, and rivers. These releases are called combined sewer overflows (CSOs). Approximately 90 percent of the CSO volume is stormwater; only 10 percent is wastewater. Figure 2-4 shows the locations of CSO outfalls in the King County system.

CSO sites that meet the Washington State standard of “an average of no more than one untreated discharge per year per outfall” are referred to as “controlled.” Those that do not meet the standards are referred to as “uncontrolled.” Uncontrolled CSOs occur year-round, mostly between September and March; single-event discharges from controlled CSOs usually occur between December and February during the largest, most intense storms.

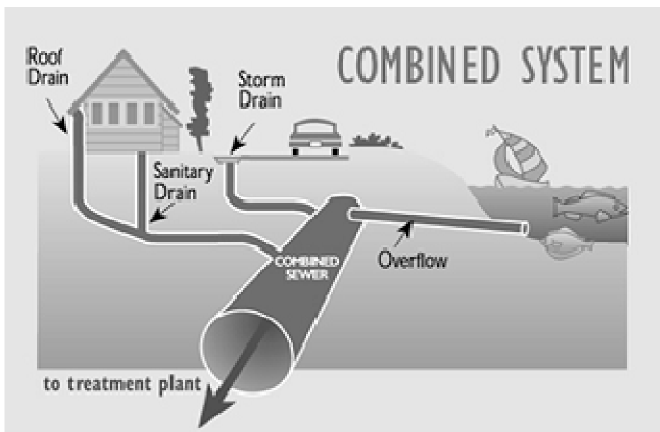

Figure 2-2. Typical Combined Sewer System

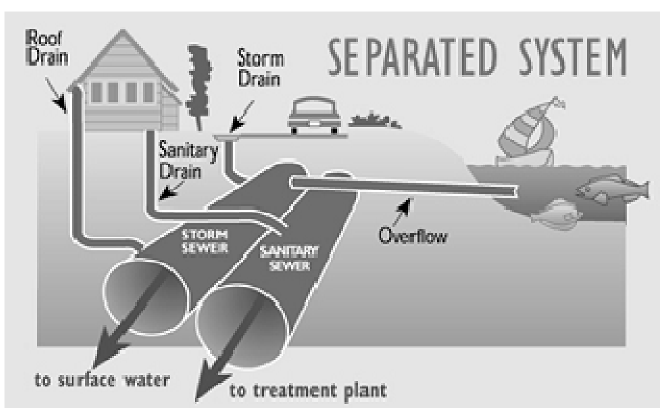

Figure 2-3. Typical Separated Sewer System

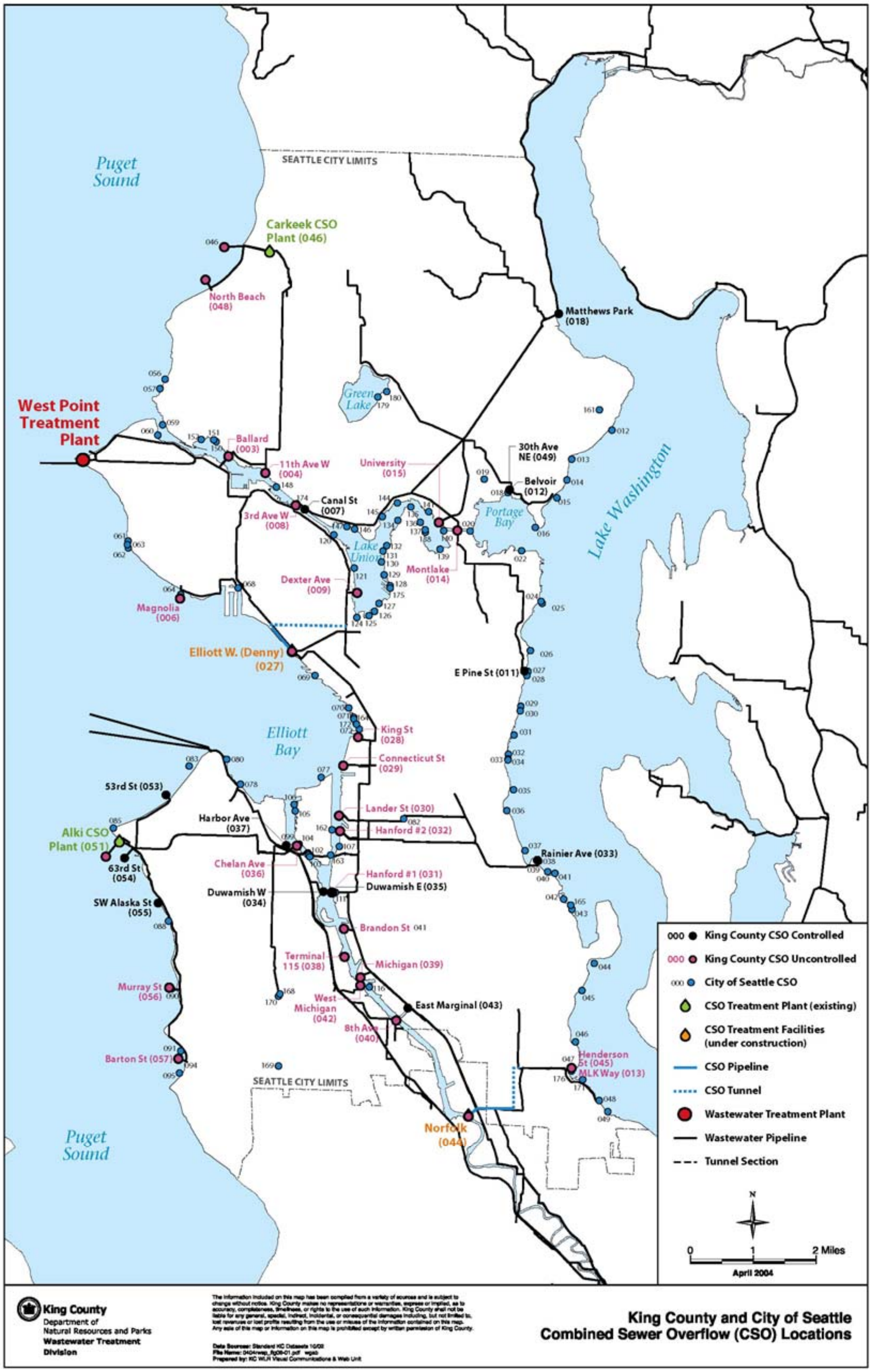

Figure 2-4. King County CSO Locations

Combined Sewer Overflow Activity in 2004

The goal of King County's CSO control program is to bring all CSOs into controlled status by 2030. The CSO control program, as outlined in the RWSP, is a continuation of a CSO control program started in the 1970s. Using Ecology's newer 24-hour inter-event interval definition, the total number of CSO events in 2003/2004 was 161, with total system volume of 1,258 MG. Of these overflows, 44 events occurred in West Point's north service area and 117 events occurred in West Point's south service area. These numbers are approximately 58 percent lower than the baseline estimated in 1981 through 1983, demonstrating CSO control progress over time (Figure 2-5). More information about specific CSOs can be found in the *2003/04 Combined Sewer Overflow Annual Report*. This report is available on the Web site listed in Appendix B.

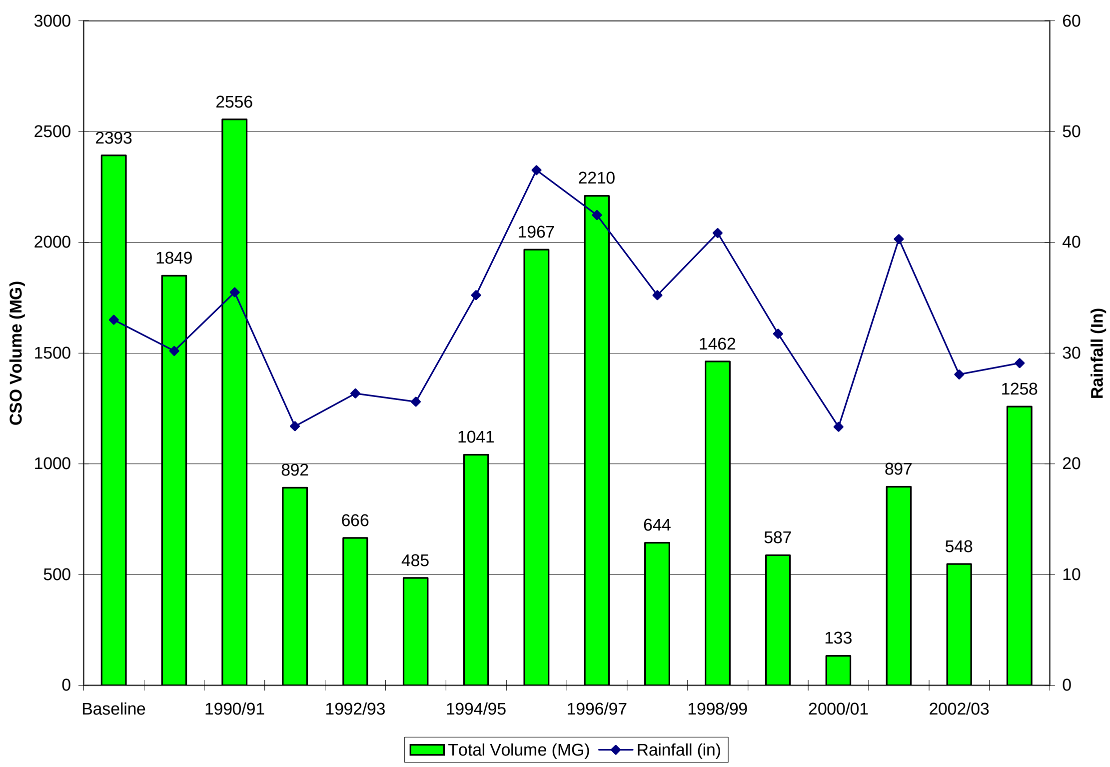

Figure 2-5. Annual CSO Volumes—1989 through 2004

During 2004, work continued on two major CSO control projects. The Denny Way/Lake Union project will control all overflows into Lake Union and will control the County's largest CSO at Denny Way near Myrtle Edwards Park in Seattle. The Henderson/Martin Luther King/Norfolk project will control three CSOs: two CSOs into Lake Washington and one into the Duwamish River. These projects will be complete in 2005.

Carkeek CSO Treatment Plant

The Carkeek plant and pump station were originally constructed to provide primary treatment to all service area flows reaching the plant. In 1994, new pipelines were completed to transfer base wastewater flows—defined by Ecology as 2.25 times the service area's average wet weather flow (AWWF) or up to 9.2 mgd—to the West Point Treatment Plant. Flows exceeding 9.2 mgd are stored at the Carkeek plant. Flows that exceed the storage capacity of the Carkeek plant receive primary treatment and disinfection at the Carkeek plant before being discharged to Puget Sound. The Carkeek outfall discharges 2,200 feet offshore at a depth of about 200 feet.

The transfer of flows from Carkeek to the West Point Treatment Plant has reduced the amount of primary effluent discharged from the Carkeek plant from approximately 1,351 to approximately 60 MG per year on average. While Carkeek has always provided disinfection to any flows discharged to Puget Sound, the new NPDES permit for Carkeek (a part of the West Point permit) includes the requirement to both disinfect and dechlorinate discharges starting January 1, 2006. In 2004, design began of systems to meet this requirement.

Alki CSO Treatment Plant

The Alki Treatment Plant was originally constructed to provide primary treatment to all service area flows from the Alki area in West Seattle. Similar to the approach used at the Carkeek plant, the West Seattle Tunnel was constructed in 1998 to transfer base combined sewage flows—up to 18.9 mgd—from Alki via the Elliott Bay Interceptor to the West Point Treatment Plant for secondary treatment. Flows in excess of 18.9 mgd receive primary treatment and disinfection at Alki before being discharged to Puget Sound. The Alki outfall discharges 1,900 feet offshore at a depth of 143 feet. The transfer of flows from Alki to the West Point Treatment Plant has reduced the amount of primary effluent discharged from the Alki plant from approximately 2,500 to less than 10 MG per year on average.

While Alki has always provided disinfection to any flows discharged to Puget Sound, the new NPDES permit for Alki (a part of the West Point permit) includes the requirement to both disinfect and dechlorinate discharges starting January 1, 2006. In 2004, design began of systems to meet this requirement.

Sediment Management Program

To address the potential for resuspended contaminated subaquatic sediments to pollute the broader environment and harm aquatic species, King County developed the *Sediment Management Plan* (SMP) in 1999 as directed in the RWSP. The plan identified and evaluated programmatic long-range remediation alternatives for consideration at seven sites near King County CSO outfalls. These seven sites represent Ecology's currently designated contaminated sediment sites in Puget Sound and the Duwamish River for which the County has some responsibility. These sites are near the following King County CSO outfall sites: Hanford Street, Lander Street, Duwamish Siphon, Brandon Street, King Street, Denny Way, and Chelan Avenue.

Ecology is granted legal authority under Washington Administrative Code (WAC) 173-204, Sediment Management Standards, to direct the identification, screening, ranking, prioritization, and cleanup of contaminated sediment sites in the state. Once a site is ranked and placed on the contaminated sites list, it may then be considered for cleanup. WAC 173-204 provides for the voluntary cleanup of contaminated sediments with oversight and guidance by Ecology. Alternatively, Ecology or the U.S. Environmental Protection Agency (EPA) may initiate enforcement actions (including cost recovery) under the Washington Model Toxics Control Act (MTCA) or the federal Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), also known as Superfund.

The County is moving ahead with the cleanup of these seven identified sites, using the voluntary approach whenever possible and participating in state or federal cleanup processes that have already begun. The County agreed with the City of Seattle, the Port of Seattle, and Boeing to undertake the first steps in the cleanup of the Lower Duwamish Waterway (LDW)—sharing the cost of developing the Remedial Investigation and Feasibility Study (RI/FS). The RI/FS is being done under an Administrative Order of Consent signed by the four parties, by EPA, and by Ecology.

Two of the seven sites sediment cleanup sites—Duwamish Siphon and Brandon Street—are in the Lower Duwamish Superfund site. Two other sediment cleanup sites—Hanford Street and Lander—are in the East Waterway at the mouth of the Duwamish River. EPA has expanded an existing Superfund site along the east shoreline of Harbor Island to cover the entire East Waterway. Cleanup was almost completed by the end of 2004 in the most contaminated portion of the East Waterway, which includes the vicinity of the Hanford Street CSO. The Superfund cleanup requirements for the East Waterway and the Lower Duwamish could result in changes in the priority and schedule of CSO control projects if upstream pollutant source control measures are not adequate.

Cleanup actions are still being determined and scheduled for the other three sediment cleanup sites.

Sediment Management Program Activities in 2004

Accomplishments in 2004 under the Sediment Management Program are as follows:

- Obtained approval for the Phase 2 plan to complete the remedial investigation (RI) of the LDW and started studies to gather the remaining data needed. Boundaries for two of the proposed early action cleanup actions were determined. Work has begun on designing those cleanups.
- Continued development of a near-field discharge model for CSOs identified in the SMP to gain state approval of proposed cleanup actions and to determine recontamination potential.
- Under a Memorandum of Agreement with the Washington State Department of Natural Resources, completed a process for cleanup decisions on state-owned aquatic lands that will streamline all future cleanups on these lands.

- Completed the Elliot Bay/Duwamish Restoration Program cleanup of the Duwamish/Diagonal CSO—identified as an early action within the LDW Superfund site. Some follow-up work will be required in winter 2005.
- Completing investigations on the Denny Way CSO. Cleanup will follow completion of the new Denny Way CSO project with its discharge through new offshore outfalls in 2005.

Planning for Future Capacity

To make sure that there is adequate time to plan, design, and build new wastewater management facilities to be ready when needed, King County must continually analyze and monitor its system. As a result of these analyses, the King County Council adopted the RWSP in 1999 to provide needed capacity through 2030. Central to the plan will be the construction of the new Brightwater Treatment Plant, which will be online by 2010.

The following analyses are part of King County's ongoing planning efforts:

- Projected population growth, type, and location using Puget Sound Regional Council data
- Economic changes affecting population growth
- Trends in water use and conservation
- Estimates of the quantity of stormwater and groundwater leaking into the system via infiltration and inflow
- Actual measured flows and solids loading over time
- New wastewater sources via contracts for service or septic system hookups

This information is then modeled and compared to existing facilities to determine where and when additional capacity must be provided by new facilities. The *2004 RWSP Update Report* describes this activity in more detail.

Infiltration and Inflow

In general, King County finds that needs for additional capacity in its wastewater system are driven less by population growth and more by the intrusion of clean water into pipes through inappropriate connections to the sewer or cracks in the pipe. This intrusion of stormwater and groundwater is called infiltration and inflow (I/I). I/I affects the hydraulic peak flow that must be managed by pipelines and plants. Measures such as water conservation have little benefit in comparison to those wet weather demands.

In 2003 and 2004, the County and local agencies completed ten pilot projects in the service area to investigate various techniques to control I/I. Some of the approaches—replacement of mains, laterals, and side sewers to homes—provided the best reduction in I/I. During post-construction flow monitoring in the Skyway area, 87 percent of the I/I was removed. In some other areas where just leaks in manholes were lined or coated, a negligible amount of I/I reduction was detected. During 2005, the County will continue to evaluate data and look at cost-effectiveness of the various techniques and approaches. As additional information about the practicality and cost-effectiveness of I/I control techniques is gathered, these techniques will be included in the County's capacity planning.

Water Conservation

Water conservation minimizes the loss of potable water into the wastewater stream, thus decreasing the demand for this valuable resource from fish-bearing streams and decreasing the base flow of wastewater to the treatment plants. Water conservation projects are being implemented as a form of "demand management" under a five-year water conservation program as a part of the RWSP. The program has committed $300,000 per year to implement these projects. The program focuses on implementation of water conservation retrofits that result in substantial water conservation savings and on public education.

Water Conservation Retrofits in 2004

In 2004, water conserving fixtures were installed in King County parks, pools, Youth Services Center, and animal shelters. These fixtures included toilets, urinals, faucets, faucet aerators, and timed showers. The fixtures are projected to save over 4 million gallons of water per year, which will result in considerable savings in energy, water, and sewer charges to these facilities.

The Millionaire Club and The Compass Center also received water conserving washing machines, toilets, and faucet aerators. These non-profit organizations provide hygiene centers and other job finding assistance for homeless and unemployed individuals.

The King County Housing Authority was provided with funds to retrofit 824 units with water conserving appliances. These retrofits complete the work with the housing authority. All of their properties are now retrofitted.

Water Conservation Public Education and Outreach Activities in 2004

In 2004, the water conservation program again contributed to the Water Conservation Coalition of Puget Sound's Regional Public Awareness Campaign. Water conservation baseball cards with the Bert the Salmon theme were distributed at a variety of events and venues. King County's water conservation Web site continued to serve as a resource.[1]

Septic Conversions

For purposes of planning, the King County Wastewater Treatment Division assumes that about 90 percent of the "sewerable" areas in its wastewater service area that did not have sewers in 2000 will be on a sewer system by 2030. The division also assumes that by 2050 all of these areas will be on sewers. This is a new assumption since issuance of the RWSP update in April

[1] The water conservation Web site can be accessed at http://dnr.metrokc.gov/wtd/waterconservation/

2004. Formerly, it was assumed that 100 percent of the sewerable area would be on sewers by 2020. The Metropolitan Water Pollution Abatement Advisory Committee's[2] Engineering and Planning Subcommittee recommended the new assumption during the I/I control program briefing that took place after the update. Achieving this sewer coverage may require local sewer agencies to extend their service and to develop policies to assist residents in acquiring wastewater service.

Detailed assessment of actual number of septic systems will be done after the end of each decade, when the census data and aerial photographs are available. Information from local agencies will be used to determine where sewers have been placed in the service area. Interim estimates of septic systems may be made when orthophotography of the service area and geographic information system coverage of local agency sewers are made available. The last orthophoto of the service area was flown in 2002.

Source Control Programs

King County operates two source control programs: the Industrial Waste Program and the Local Hazardous Waste Management Program. Both programs work to control pollutants at their source, thereby keeping them out of the wastewater system and, in turn, out of surface waters and the environment. The two programs complement each other. The Industrial Waste Program focuses on larger businesses in a regulatory manner, issuing permits and discharge authorizations under a federally mandated pretreatment program. The Local Hazardous Waste Management Program focuses on smaller businesses and on households in a non-regulatory manner, providing technical assistance, resources, and education under a state-mandated program.

Industrial Waste Program

This section describes the Industrial Waste Program, the Lower Duwamish Waterway Source Control Project that began in 2002, and other activities completed through the program in 2004.

Description of the Program

The Industrial Waste Program regulates industrial wastewater discharged into the King County wastewater system. The core work of the Industrial Waste Program involves identification of conditions under which companies may discharge to the County wastewater system, and then following up with monitoring, inspections, and enforcement. The purpose of these activities is to ensure that industries treat wastewater before discharging it in order to control harmful substances such as metals, oils, acids, flammables, organic compounds, gases, or solids. This program protects surface water quality, the environment, public health, the wastewater system and its workers, and biosolids quality.

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[2] The Metropolitan Water Pollution Abatement Advisory Committee (MWPAAC) is a committee composed of representatives from the local wastewater agencies that King County serves.

The Industrial Waste Program may regulate any industry, from largest to smallest, if the industry discharges wastewater to the wastewater system. To do this, the Industrial Waste Program issues two main kinds of discharge approvals: permits and discharge authorizations. Permits are issued to industries that discharge more than 25,000 gallons per day and/or that are included in federally regulated categories. EPA requires at least 20 categories of industries to get permits, whatever their size or quantity of wastewater. Permits have more comprehensive requirements than discharge authorizations and require a company to self-monitor its discharge.

Industrial waste investigators inspect facilities before issuing discharge approvals and also inspect those with approvals to see that they are complying with regulations. Most are companies that are required to self-monitor their discharges. Industrial waste specialists take verification samples at facilities to see whether wastewater complies with regulations. When violations are found, follow-up inspections and sampling are done to determine that violating conditions have been eliminated.

The Industrial Waste Program issues a notice of violation when a company discharges more contaminants or volume than allowed, violates conditions of its discharge approval, or fails to submit required reports. For enforcement, the Industrial Waste Program uses tools such as compliance schedules, fines, charges for monitoring and inspections, and cost recovery for damages.

Lower Duwamish Waterway Source Control Project

In 2002, the Industrial Waste Program initiated the Lower Duwamish Source Control Project in support of the Sediment Management Program. The project is headed by Ecology. Its purpose is to coordinate with sediment cleanup efforts to identify and manage sources of chemicals to site sediments. Its goals are to minimize the potential for chemicals in sediments to exceed the Sediment Management Standards (WAC 173-204) and the Lower Duwamish Waterway sediment cleanup goals.

As part of this project, the King County Industrial Waste Program and Seattle Public Utilities are spearheading a joint inspection project that includes Public Health–Seattle & King County and King County’s Hazardous Waste Program. Participating agencies inspect businesses for discharges to stormwater, wastewater, and combined sewers and for compliance with hazardous waste regulations. Involving multiple agencies in a variety of different regulations reduces redundancy and costs. Each business receives only one inspection unless the inspectors find problems that need follow-up visits.

In 2004, inspectors worked in drainage basins affecting two early action sites to be cleaned up through the Lower Duwamish Superfund process: (1) the Diagonal/Duwamish drainage basin, a large basin that extends east and north from the shared King County and Seattle drainage pipe at Diagonal Way, and (2) the Slip 4 basin, an area including and surrounding the north part of the King County Airport. Inspectors from Seattle Public Utilities and King County completed a total of 803 business inspections in the Duwamish/Diagonal basin and 46 inspections in the Slip 4 basin. These 849 inspections completed the initial round of inspections in the Duwamish/Diagonal basin and the majority of the inspections in the Sip 4 basin. As was the case in 2003, the most common problems were related to stormwater and hazardous waste management.

In addition to inspections, the Lower Duwamish Source Control Project includes an ongoing phthalate source study. Phthalates are plasticizers that are widely produced and found in both consumer and industrial products such as perfume, plastics, lubricants, and pesticides. Phthalates appear to be the chemical with the most significant potential to recontaminate waterway sediments. The intent of the study is to identify specific sources to storm drains and sanitary sewers and to test industrial and household products for phthalate content. Results of the study to date are as follows:

- Motor vehicle components (such as particles from brake pads and tires) may be a source of phthalates via roadway runoff.
- Low- or non-detected levels of phthalates in almost all vehicle cleaning and maintenance product tests indicate that businesses near the Lower Duwamish Waterway do not need to change products for these activities.
- More research is needed to locate substantial sources of phthalates.

Industrial Waste Program Activities in 2004

During 2004, 136 permits and 286 industrial waste discharge authorizations were in effect and 274 inspections were conducted. Table 2-2 shows the number of compliance samples collected versus the number of violations detected. Following the table is a brief summary of the enforcement actions that were taken.

During 2004, Notices of Violation for 54 violations were issued to 34 companies. Several companies had multiple violations in more than one category. The violations were as follows:

- 20 companies had 34 discharge violations.
- 7 companies had 8 permit/code violations.
- 10 companies had 12 reporting violations.

The company with the most violations (eight discharge violations) was Burlington Environment–Kent, a centralized waste treatment facility in Kent.

The Industrial Waste Program issued four fines in 2004, totaling $5,942. The largest fine ($3,442) was issued to WestFarm Foods in Issaquah.

None of the violations caused NPDES exceptions at King County treatment plants.

Table 2-2. Number of Discharge Compliance Samples and Discharge Violations in 2004

Parameter	Compliance Samples	Post-Violation	Discharge Violations
Cyanide			
Total cyanide	129		
Cyanide amenable to chlorination	29		
Metals	489	8	10
Organics			
BNA	49		10
VOA	220		1
Fats, oils, and grease (FOG)			
Total	0		
Polar[a]	43		
Non-polar	325		
pH (field)[b]	553	3	1
Surcharge	267		

Note: The information in this table will appear in the 2004 annual pretreatment report.

a The visual free-floating fats, oils, and grease (FOG) test was used to assess the presence of polar (animal-vegetable) FOG. No laboratory analyses were done.

b The number of pH samples is somewhat misleading because it shows only discrete pH samples collected and analyzed in the field, not readings from continuous pH measurement.

Local Hazardous Waste Management Program

King County participates in a regional program that addresses hazardous wastes from small businesses and households. This program, called the Local Hazardous Waste Management Program, is a consortium of the King County Department of Natural Resources and Parks (the Water and Land Resources Division and the Solid Waste Division), the City of Seattle (Seattle Public Utilities), Public Health–Seattle & King County, and the Suburban Cities Association. The program provides technical assistance, reimbursement, and recognition to businesses that generate small quantities of hazardous waste. It also provides collection services for household hazardous wastes as well as public education aimed at proper handling and reduction in use of hazardous household products.

The Local Hazardous Waste Management Program oversees King County's Integrated Pest Management (IPM) Program for all County operations. IPM has been instrumental in substantially reducing County pesticide use (by more than 60 percent since 2000) and in the proper disposal of tons of old pesticides that the County no longer needs. King County has incorporated many innovative alternative pest management approaches and is working with local cities to share experiences and resources.

These Local Hazardous Waste Management Program activities helped to reduce air emissions within the wastewater system that are caused by solvents and other hazardous air pollutants. In addition, potentially problematic chemicals that could affect secondary treatment processes have been reduced. As a result, fewer heavy metals and organics are discharged into Puget Sound and fewer of these pollutants accumulate in the solids, making biosolids products more useable and more acceptable to customers and the public.

Hazardous Waste Program Activities in 2004

In 2004, the Local Hazardous Waste Management Program accomplished the following:

- Inspected and educated businesses, which resulted in reduction of hazardous waste generation by over 14,000 pounds.
- Convinced businesses to divert 71,000 pounds a year of improperly disposed hazardous waste to proper disposal. This total includes diversion of 38,000 pounds a year of mercury- and silver-bearing waste from the wastewater system and over 7,000 pounds of mercury-contaminated solids (mostly fluorescent tubes) from disposal as solid waste.
- Helped businesses to move 26,000 gallons of hazardous chemicals from unsafe storage near floor drains or outdoors into contained and covered storage areas.
- Helped businesses safely dispose of 1,800 pounds of stockpiled chemicals before they could become a problem.

The following success story demonstrates how the program works, in this case with other agencies, to achieve the kind of results listed above.

The Interagency Resource for Achieving Cooperation (IRAC) created a Troublesome Sites workgroup to coordinate the work of different agencies in comprehensively resolving multiple problems at sites that have been highly resistant to compliance. The workgroup attempts to develop the best overall strategy for achieving the desired compliance. It convenes when a site is identified and interested parties express an interest in working together to resolve repeated environmental and health violations.

Japanese Auto Wrecking (JAW) was nominated as a troublesome site in 2002 by an inspector from Ecology. For several years prior, numerous agencies had attempted to work with JAW to encourage them to comply with a range of environmental, health, and safety regulations, but conditions continued to degrade. (The business originally occupied approximately 1.7 acres on a 15-acre site. It was located within 0.25 mile of the Green River and within 0.5 mile of residences.)

The workgroup consisted of staff from the King County Department of Natural Resources and Parks, King County Department of Development and Environmental Services (Code Enforcement Services), the King County Prosecuting Attorney’s Office, Public Health–Seattle & King County, the Seattle Police Department, the Washington State Attorney General’s Office, the Washington State Patrol, the Washington State Department of Labor and Industries, the Washington State Department of Licensing, Ecology, and EPA.

During the course of joint visits and investigations, inspectors observed oil floating on surface water, strong petroleum odors, puddles of used anti-freeze, leaking engines, crushed and leaking lead acid batteries on the ground, and piles of debris on the ground. Workers at the site reported dumping of thousands of gallons of gasoline directly into the soil at several locations.

The workgroup developed a strategy by determining which agencies had the best resources and enforcement authority. Meetings were held to coordinate, share information, and continue to strategize. In January 2003, the Washington State Department of Labor and Industries closed the site on the basis of unsafe working conditions. JAW had been gradually encroaching on surrounding property and by the time it was closed, the business had taken over approximately 5.72 acres in addition to the original 1.7 acres that it leased.

In February 2003, EPA became involved because of the potential for leakage from buried chlorine gas cylinders. On May 2, 2003, EPA defined the entire 15-acre property as the site area (including the approximately 8 acres formerly occupied by JAW). The operator was arrested in December 2004 by State Patrol officers and now faces ten criminal charges, including four felony counts of illegal hazardous waste disposal.

Resource Recovery Programs

King County has long recognized that the liquids and solids leaving the wastewater treatment process are not “wastes” for disposal, but are useful resources that can be recycled to benefit the environment or replace other high-demand resources. The County currently recycles three of these resources as useful products: biosolids, methane (digester gas), and reclaimed water.

Biosolids

On average, King County produces approximately 120,000 wet tons of biosolids each year—all of which is recycled for use in forestry, compost, and agricultural applications. There are two ongoing efforts in King County’s management of biosolids: the recycling program and new technology assessment. The recycling program continues to produce Class B biosolids via anaerobic digestion at all treatment plants. Class B processing relies on application of the biosolids to a controlled-access site, such as a forest or agricultural field, to complete the pathogen reduction process.

Biosolids Activities in 2004

To ensure the appropriate use of biosolids, King County continued to monitor water quality of streams near biosolids application sites in 2004. As with previous years, the County found little effect to receiving waters from biosolids.

The Technology Assessment program is evaluating new technologies that have the potential to increase the efficiency or reduce the potential impacts of solids processing and that have the potential to produce Class A biosolids. Pilot test programs and final reports have been completed on advanced biosolids dewatering/drying (Centridry™), vertical shaft aerobic thermophilic digestion (VERTAD™), anaerobic thermophilic digestion, anoxic gas flotation thickening (AGF), and solids pyrolysis/gasification using microwave energy (SAGE™). With the exception of thermophilic digestion, the majority of the evaluated technologies demonstrated only limited success, had serious operational problems, or would not adequately scale up to King County production levels and thus did not receive further consideration.

In 2004, the Technology Assessment program initiated the Class A Biosolids Workplan Project. The purpose of the project is to produce an integrated plan that presents a site-specific preferred alternative for producing and managing Class A biosolids at the South Treatment Plant and the West Point Treatment Plant. (Plans for processing and management of biosolids produced at the future Brightwater Treatment Plant are being developed separately.) The plan will include a technology and marketing approach that represents a consensus of plant and biosolids program staff and management that can be implemented based on a variety of potential factors. Separate recommendations will be prepared for each plant, including technology, product characterization, current market, site layout, capital and operating costs, and potential construction issues.

Three upset or pre-upset conditions have been experienced at digesters at the West Point plant in recent years. A digester upset can be caused by a variety of conditions and is usually characterized by increased odor production, decreased gas production, and decreased or lost capacity to convert and stabilize flows. These solids processing problems indicate limitations to West Point’s effective capacity under certain conditions. Digester profiling and other preliminary analyses and testing were completed in 2004. Design work is scheduled for 2005: the needed improvements will be made over a three-year period.

Methane (Digester Gas)

A byproduct of biosolids production is methane (digester gas). Both the West Point and South Treatment Plants recover this gas, but each uses it differently. The South Treatment Plant scrubs digester gas and sells the gas to Puget Sound Energy for distribution in its natural gas system. The gas is also used to generate electricity in a 1-megawatt fuel-cell power plant and to heat water in a methane-fueled boiler (completed the end of 2003). West Point uses the gas to fuel engine generators that produce electricity and to power pumps. The electricity produced is used to power plant operations; any excess electricity is sold to Seattle City Light.

Production and use of methane continued at both plants in 2004, and investigation of new uses and technologies progressed. Construction of the fuel-cell project at South Treatment Plant was completed and began a two-year demonstration period in April 2004. If the demonstration is successful, the facility will be used on an ongoing basis.

Reclaimed Water

King County began producing reclaimed water at its West Point and South Treatment Plants in the early 1990s. This water is used in plant operations and irrigation. In 1997, the Water Reuse

Policy Development Task Force adopted the following needs statement: “Recycling and reusing highly treated wastewater effluent should be investigated as a significant new source of water.”

To focus the County’s efforts to reclaim more water, a five-year *Water Reuse Work Plan* was transmitted to Council in December 2000, as required by the RWSP. The plan recommended two primary implementation efforts: a technology demonstration project and a satellite treatment facility.

The County worked with a Stakeholder Task Force to solicit and rank nominations from public and private parties interested in partnering to implement water reuse demonstration projects. The Sammamish Valley Reclaimed Water Production Facility, which would produce water for irrigation, was selected for implementation. King County began predesign on the facility in December 2001.

In 2003, the local community raised concerns about the suitability of the site for a reclamation plant. As a result, alternative sites and configurations were explored. The King County Council, in a proviso to the 2004 County budget, required the submittal of a report by April 15, 2004. The report was to (1) review how an interim satellite reclaimed water production facility in the Sammamish Valley would be consistent with the adopted goals and policies of the RWSP, (2) account for life-to-date expenditures, and (3) outline a revised scope and budget for the interim facility. The report also was to demonstrate how the interim project would be related to and integrated with any future reclaimed water production at the Brightwater Treatment Plant.

Reclaimed Water Activities in 2004

The Sammamish Valley proviso report was submitted to and approved by Council in April 2004. The approval released the $5 million withheld by the proviso. Subsequently, in fall 2004, the Council eliminated the budget for the Sammamish Valley Reclaimed Water Production Facility. The Brightwater design team will study the possibility of delivery of reclaimed water from the Brightwater Treatment Plant to the valley.

King County is in the process of establishing a Memorandum of Agreement with the Cascade Water Alliance to initiate a regional water supply planning process. As a part of the process, potential reclaimed water users will be identified. In part, as a result of this process, areas in Covington, Black Diamond, and Soos Creek have been identified as having irrigation demands that could be met with reclaimed water if the reclaimed water could be made available.

Chapter 3

Monitoring the Health of King County Waters

In the Puget Sound region, water is an integral part of our surroundings, economy, and way of life. King County acts as a steward of these waters and is committed to keeping them clean. The quality of our waters has improved dramatically over the years as the result of the development of a regional wastewater collection and treatment system and our cooperative efforts to implement pollution control programs. The County's goal is to ensure that our actions are not degrading the beneficial uses of our valuable water resources. Understanding the health of our waters is the starting place for achieving this goal.

This chapter describes how the County measures the health of water bodies in its wastewater service area by using chemical, physical, and biological indicators. It also describes how the County monitors these indicators to identify changes in water quality that may require measures to restore the health of a water body. Some of the monitoring programs are ongoing; some are special short-term studies.

Washington State Water Quality Standards

The primary objective of the federal Clean Water Act (CWA) is to restore and maintain the integrity of the nation's waters. This objective translates into two national goals: to eliminate the discharge of pollutants into the nation's waters and to achieve fishable and swimmable waters. The first goal is met through the National Pollutant Discharge Elimination System (NPDES) permit program, which sets limits on pollutants discharged from distinct and identifiable sources, called point sources, such as King County's wastewater treatment plants and municipal stormwater systems. The second goal is met by developing pollution control programs to meet specific water quality criteria for water bodies.

To meet the second CWA goal, the Washington State Department of Ecology (Ecology) put into regulation a classification-based system in which each water body is assigned to one of eight classes: four freshwater classes (Class AA, Class A, Class B, Lake Class) and four marine classes (Class AA, Class A, Class B, and Class C). In June 2003, Ecology adopted several changes to its standards, reformatting water uses and criteria from the previous classification-based standards to use-based standards. These changes reflect the latest scientific information and state and federal requirements—all aimed at making our waters clean and safe for people, fish, and wildlife. Table 3-1, Table 3-2, Table 3-3, and Table 3-4 show the revised Washington State classification system and corresponding standards (WAC 173-201A).

Table 3-1. Washington State Classification System and Corresponding Standards for Marine Water Aquatic Life Uses

Parameter	Unit	Extraordinary Quality	Excellent Quality	Good Quality	Fair Quality
Dissolved oxygen 1-day minimum	mg/L	> 7.0	> 6.0	> 5.0	> 4.0
Temperature 1-day maximum	°C	≤ 13	≤ 16	≤ 19	≤ 22
PH	standard unit	7.0–8.5 human caused variation < 0.2	7.0–8.5 human caused variation < 0.5		7.5–9.0 human caused variation < 0.5
Turbidity	NTU	≤ 5 over background turbidity when background turbidity is ≤ 50; ≤ 10% increase when background turbidity > 50		≤ 10 over background turbidity when background turbidity is ≤ 50; ≤ 20% increase when background turbidity > 50	

Table 3-2. Washington State Classification System and Corresponding Standards for Marine Water Uses—Bacteria Criteria

Parameter	Unit	Criteria
Fecal coliform (for primary contact and shellfish)	Colonies /100 mL	Geomean ≤ 14; ≤ 10% > 41
Enterococcus (for secondary contact)	Colonies /100 mL	Geomean ≤ 70; ≤ 10% > 208

Note: See the glossary for definitions of primary and secondary contact.

Table 3-3. Washington State Classification System and Corresponding Standards for Freshwater Aquatic Life Uses

Parameter	Unit	Char (Bull Trout & Dolly Varden)	Salmon & Trout Spanwing, Core Rearing, & Migration[a]	Salmon & Trout Spanwing, Noncore Rearing, & Migration	Salmon & Trout Rearing & Migration[b]	Lakes
Dissolved oxygen 1-day minimum saturation not to exceed 110%	mg/L	> 9.5	> 9.5	> 8.0	> 6.5	No human-caused decrease > 0.2 below natural conditions
Temperature 7-day average of the daily maximum	°C	≤ 12	≤ 16	≤ 17.5	≤ 17.5	No human-caused increase > 0.3 above natural conditions
PH	standard unit	6.5–8.5	6.5–8.5	6.5–8.5 with a human caused variation within the above range of < 0.5		
Turbidity	NTU	≤ 5 over background turbidity when background turbidity is ≤ 50; ≤10% increase when background turbidity > 50			≤ 10 over background turbidity when background turbidity is ≤ 50; ≤ 20% increase when background turbidity is > 50	

[a] Station A438 in WRIA 08 is listed in this category.
[b] Stations 0305, 0307, 0309 in WRIA 09 are listed in this category.

Table 3-4. Washington State Classification System and Corresponding Standards for Freshwater Contact Recreational Uses

Parameter	Unit	Extraordinary Primary Contact[a]	Primary Contact[b]	Secondary Contact[c]
Fecal coliform	Colonies/ 100 mL	Geomean ≤ 50; ≤ 10% > 100	Geomean ≤ 100; ≤ 10% > 200	Geomean ≤ 200; ≤ 10% > 400

Note: See the glossary for definitions of primary and secondary contact.

[a] Station A438 in WRIA 08 is listed in this category.
[b] Station X438 in WRIA 08 is listed in this category
[c] Stations 0305, 0307, and 0309 in WRIA 09 are listed in this category.

The water quality standards for ammonia have also changed (WAC 173-201A-240). For marine waters, the acute standard is 0.233 mg/L (un-ionized NH_3) and the chronic standard is 0.035 mg/L (un-ionized NH_3). A calculation based on salinity, temperature, and pH is used to convert total ammonia concentrations to un-ionized ammonia. The freshwater standards vary depending on the presence of salmonids or other early-life stage fish, and involve a calculation based on temperature and pH. The other toxics standards were not changed.

When waters do not meet standards, Section 303(d) of the CWA requires that these waters be added to a “303(d) list.” The 303(d) list is published every three to five years. Ecology released the most recent list for public review on January 15, 2004. In October 2004, Ecology released a second draft of this list and solicited comments through December 2004. It is expecting to finalize the list in 2005. Once listed, the water body must be studied and controls must be put into place that will correct conditions so that it meets standards. Controls often involve dividing the pollutant load into allocations that the water body can assimilate and still meet the standards. This process is called a Total Maximum Daily Load (TMDL). TMDLs are described in more detail in Chapter 5 of this report.

The biological, chemical, and physical parameters used to assess a water body’s health under the Sstate’s classification system are fecal coliform bacteria, dissolved oxygen, temperature, pH, ammonia, turbidity, and a variety of chemical compounds. Each parameter is described below.

Bacteria

Fecal coliform and *Enterococcus* bacteria live in the intestines of warm-blooded animals including humans, wildlife, and pets, and are used as an indicator of human fecal pollution. Most fecal coliform bacteria do not cause disease, but they may coexist with bacteria and viruses that could pose a public health risk. Because it is technically difficult and costly to distinguish whether the bacteria found in the water came from humans or from other warm-blooded animals, the usefulness of fecal coliform bacteria as a predictor of human health risk is limited. Ecology recently reviewed whether other bacteria indicators such as *Enterococcus* or *E. coli* should be used as the state regulatory standard. It has proposed that fecal coliform be applied to waters used for shellfish growing and primary contact recreation and that *Enterococcus* be applied to waters used for secondary contact recreation. U.S. Environmental Protection Agency (EPA) approval is anticipated to occur in mid-2005. Until then, the previous fecal coliform–based criteria will be used.

Dissolved Oxygen

Aquatic (water-based) plants and animals require a certain amount of dissolved oxygen (DO) for respiration and basic metabolic processes. Waters that contain high amounts of DO are generally considered healthy ecosystems. DO concentrations are most important during the summer season when oxygen-depleting processes are at their peak. DO levels in waters bearing fish of the salmon family (salmonids) are given special consideration, because salmon are an important cultural, recreational, and economic resource for the Northwest and are recognized as being in danger of extinction.

Temperature

Temperature influences many of the chemical components of the water, including DO concentration. Temperature also exerts a direct influence on the biological activity and growth and, therefore, the survival of aquatic organisms. Temperature levels in waters bearing salmonids are also very important.

pH

The pH of water is a measure of the concentration of hydrogen ions. A pH value higher than 7 (meaning there are fewer free hydrogen ions) is considered alkaline or basic; a value of 7 is considered neutral; and a value of less than 7 is considered acidic. The pH of water determines the solubility and biological availability of chemical constituents such as heavy metals and nutrients. Metals tend to be more toxic at lower pH values because they are more soluble. Likewise, at lower pH values nutrients are in soluble form and are therefore more readily taken up by aquatic plants.

Turbidity

Turbidity refers to the amount of suspended material in water. It is measured by the amount of light scattered in a water sample and is reported in Nephelometric Turbidity Units (NTU). More material in the water results in a greater amount of scattered light and a higher NTU reading. In general, increases in turbidity result from human activities in the watershed such as land development and construction that cause loss of vegetation, increased runoff, and increased erosion). The effects of high turbidity can include diminished light penetration for plant growth and DO production, sedimentation of gravel beds used by spawning fish, and waters that are too “dirty” to enjoy.

Usually turbidity is used to evaluate the impact of a pollutant source. Two measurements are made to measure the change in turbidity from a source: one upstream of a discharge point (background levels) and another downstream. Because it often monitors waters where there is no identifiable pollutant source, King County measures only one point in a stream and then compares it to the average of all measurements for that site. Values exceeding the average by 5 NTU or more are considered substandard.

Other Water Quality Standards

Other standards have been set for special uses. These standards include both numeric chemical-specific standards for the protection of aquatic species and of human health and more judgment-based narrative standards. Standards have been developed for water quality and for subaquatic sediments.

Aquatic Organism Health Standards

Standards to protect aquatic organisms have been developed that define acceptable levels for individual chemicals. Acute standards protect aquatic organisms from immediate and severe impacts such as death or poisoning, while chronic standards protect against sub-lethal effects such as reduced growth or reproduction.

Human Health Standards

Chemical-specific standards for water or sediment are designed to prevent harm to humans as they are transmitted to humans through the food chain.

Nutrient Standards

Ammonia is the only nutrient that has a numeric water quality criterion. The Washington State ammonia standard is based on un-ionized ammonia. However, for total ammonia, which is measured by King County, the state uses EPA's criteria concentrations. These total ammonia criteria are based on temperature, salinity, and pH of the water. Ammonia tends to have a seasonal cycle, as do other nutrients. Higher concentrations typically occur in summer and fall and at deeper depths, corresponding to decay of organic nitrogen from phytoplankton.

Sediment Quality Standards

In the early 1990s, Washington State became the first state to implement Sediment Quality Standards for marine waters, providing a new tool to assess the cumulative impacts of chemicals on the environment. The standards include the sediment quality standards (SQS), which are chemical-specific criteria that designate what is considered healthy sediment quality, and a threshold called the Cleanup Screening Level (CSL) for considering sediment remediations. When these chemical criteria are exceeded, toxicity testing is used to verify the adverse impact.

Non-Regulatory Water Quality Indicators

Other measures have been developed over time to characterize water quality and to provide comparisons that guide the development of water quality protection efforts. While these measures may not have the enforcement capabilities of regulatory standards, they are time-honored methods based on the experience of water quality professionals. Two indices are used for freshwater assessment: the Trophic State Index and the Water Quality Index. In marine waters, chlorophyll-*a* is used as a non-regulated indicator of phytoplankton blooms.

Trophic State Index

A common way to characterize the health of lakes is by the numerical Trophic State Index (TSI). With the TSI, lakes can be rated and compared according to the level of biological activity (such as level of nutrients and algal growth). This index provides a standard measure to compare lake quality on a scale of 0 to 100. Each major division (10, 20, 30, and so forth) represents a doubling of algal biomass and is related to nutrients and transparency (water clarity). The summer mean values of the three most common lake parameters—Secchi depth transparency, total phosphorus, and chlorophyll-*a* concentrations—are used to develop the TSI. The calculated TSI values provide three ranges of lake classification—oligotrophic, mesotrophic, and eutrophic—as shown in Table 3-5.

Table 3-5. Average Summer (June–September) Trophic State Index (TSI) Values

TSI Value	Classification	Characterization
< 40	Oligotrophic	Low biological productivity resulting in high water clarity, low algal levels, and low phosphorus concentrations
40–50	Mesotrophic	Moderate levels of plant and animal activity resulting in moderate water clarity, moderate, algal levels, and low phosphorus concentrations
> 50	Eutrophic	High biological productivity resulting in low water clarity, high algal levels, and high phosphorus concentrations

Secchi Depth Transparency

Secchi depth transparency is a measure of water clarity or transparency as measured by viewing a Secchi disk—an 8-inch disk for fresh water or a 12-inch disk for marine water, with alternating black and white quadrants. The disk is lowered into the water until the observer can no longer see it. This depth of disappearance is called the Secchi depth. Algae, soil particles, and other materials suspended in the water affect transparency. The Secchi depth will decrease as these factors increase. In King County, clarity tends to be lower during periods of high algal growth (spring and summer) and during periods of high stormwater flows (winter).

Phosphorus

Nutrients such as nitrogen, phosphorus, and silica are necessary for plant and animal growth. An excessive amount of nutrients, however, can increase the growth of aquatic plants, which subsequently decay and deplete oxygen to levels incapable of sustaining aquatic organisms. Phosphorus is the primary nutrient of concern in freshwater systems. If present in excess amounts, phosphorus can cause nuisance algal blooms or, on occasion, toxic algal blooms. Phosphorus enters water bodies via discharge of detergents, runoff containing fertilizers, or seepage from failing septic systems. Sediment can also be a source of phosphorus. Phosphorus readily binds to soil particles, is washed into the lakes, and then is later released into the water column when DO concentrations fall below 0.2 mg/L.

Chlorophyll-*a*

Chlorophyll is the green pigment in plants that allows them to create energy from light (photosynthesis). Chlorophyll serves as an indirect measure of the amount of plants and algae in the water column. Chlorophyll-*a* is a measure of the portion of the pigment that is still actively photosynthesizing at the time of sampling.

Water Quality Index

The Draft Water Quality Index (WQI) was established by Ecology in 2002[1] as a means to rank the conditions of streams. The WQI integrates a series of key water quality parameters into a single number that can be used for comparison over time and between locations. King County has modified the WQI slightly to achieve a better representation of its rivers and streams.

The WQI for a stream is expressed as a number ranging from 10 to 100; a higher number indicates better water quality. For temperature, pH, fecal coliform bacteria, and DO, the index reflects sampling results relative to levels required to maintain beneficial uses (based on State standards). Because there are no state standards for nutrients and sediments, results are expressed relative to expected conditions in a given ecoregion. To determine a WQI, results for multiple constituents are combined and aggregated over time to produce a single score for each sampling station. In general, stations with scores of 80 and above meet expectations for water quality and are of “low concern,” stations with scores of 49 to 80 indicate “moderate concern,” and stations with scores below 40 do not meet expectations and are of “high concern.”

Chlorophyll-*a* (Phytoplankton Blooms) in Marine Waters

In marine waters, as in the freshwater Trophic State Index described above, chlorophyll-*a* concentrations are used as the best available indicator of phytoplankton biomass because planktonic algae contain this photosynthetic pigment. Although not an exact measurement, high chlorophyll-*a* concentrations are useful for evaluating the presence and frequency of phytoplankton blooms. An increased frequency of phytoplankton blooms on a yearly basis serves as an indicator of possible nutrient excess and potential water quality problems.

Ongoing Monitoring Programs

Ensuring the health of county water bodies, and so the health of the people using them, is the purpose of King County’s water quality efforts. The County’s extensive water monitoring programs provide the high quality data from which decisions can be made to direct these efforts.

Monitoring programs are also designed to protect the significant investment in water quality improvements made by the people of King County. Although nearly all wastewater is now either

[1] Hallock, D. 2002. *Washington’s Water Quality Index.* Draft report prepared for the Washington State Department of Ecology.

treated with an onsite septic system or sent to treatment plants, water quality monitoring is still an important tool to help ensure continued wastewater system integrity and to identify any threats to the gains we have already made to improve water quality. King County regularly assesses the impact of its own operations by measuring the quality of the effluent from each of its wastewater treatment facilities, the surrounding water, and nearby beaches to ensure that the facility is meeting regulatory requirements. A summary of the monitoring programs is shown in Table 3-6; a map of monitoring locations, also known as stations, is included as Figure 3-1. The table and map include information on special studies, described later in this chapter.

King County's laboratory system supports the monitoring programs. The system includes three process laboratories—one at each treatment plant (South, Vashon, and West Point)—and an environmental laboratory located centrally in metropolitan Seattle. The process laboratories perform conventional chemistry and microbiology analyses in support of plant process optimization and NPDES requirements. The process laboratories also provide support to capital projects such as effluent reuse and the advanced wastewater technology (AWT) program. The environmental laboratory provides support for NPDES permit requirements, the biosolids source control program, the combined sewer overflow (CSO) control program, and the lakes, streams and marine monitoring programs.

Ambient Monitoring

Ambient refers to the general, routine monitoring of a water body, without singling out specific pollutant sources. Ambient monitoring stations are located in lakes and streams and in the Puget Sound to monitor the long-term environmental quality of these waters.

The objectives of ambient monitoring programs are as follows:

- Assess existing conditions for water bodies, determine if Washington State Water Quality Standards are met, and track progress in correction of 303(d) listed parameters
- Determine long-term water quality trends for King County waters
- Identify successes in water quality protection, and make recommendations for future efforts
- Provide comparison for data collected near King County outfalls
- Monitor the integrity of the wastewater conveyance system and track water quality parameters of interest to the Wastewater Treatment Division (WTD)
- Provide information on historical and existing conditions in support of special projects such as the Sammamish/Washington Analysis and Modeling Program (SWAMP) and the WTD Habitat Conservation Plan

Freshwater Ambient Monitoring

Freshwater ambient monitoring programs run by King County include the major lakes, small lakes, rivers and streams, and swimming beach programs.

Each of the major lakes in the Cedar-Sammamish watershed has one or more sampling stations located in its deep central basin where the influence of the shoreline is muted by the mixing action of wind and waves. Changes observed over time at these sites reflect broad large-scale or landscape-scale changes in the watershed and the lake. Other sampling stations are distributed around the shoreline of the lake, primarily off the mouths of inflowing streams. Changes in water quality at these stations are more directly influenced by shoreline activities and by the quality and quantity of inflowing stream water.

Rivers and streams in the King County service area are monitored if they cross sewer trunk lines or if they are considered a potential or significant source of pollutant loading to a major water body. Monthly baseflow samples have been collected along some of the tributaries flowing into Lake Washington, Lake Sammamish, and the Green River system since 1979. Beginning in 1987, storm-influenced samples have been collected to increase our understanding of wet weather impacts on local water quality.

Over 100 volunteers monitor 51 lakes in the area as a part of the Lake Stewardship Program. Information on lake level, water quality, and aquatic plants helps County staff to better understand how individual lakes work and how best to preserve their quality. The County uses the lake monitoring results to do the following:

- Accumulate baseline data
- Assess long-term trends
- Estimate seasonal or water column variability
- Identify problems and propose management solutions
- Educate and provide long-term stewardship opportunities

Data collected by volunteers are reported informally in King County's quarterly newsletter, *The Lake Steward*, and formally in the annual *Lake Monitoring Report*.

The Stream Sediment Monitoring Program was begun in 1987 in WRIAs 08 and 09 as part of the overall Lakes and Streams Ambient Monitoring Program. An updated 10-year program began in 2004 to monitor the effects of all sources (point sources and stormwater) to the streams. Additional parameters were added to the existing sediment monitoring program to better understand the range of contaminants that affect sediment quality. A two-tiered sampling design will allow for the assessment of sediment quality in individual stream basins and for analysis of long-term trends.

Every summer since 1996, swimming beaches on Lake Sammamish, Lake Washington, and Green Lake have been surveyed to determine levels of bacterial pollution. King County evaluates the relative human health risks and necessity for beach closures in cooperation with Public Health–Seattle & King County and with local parks departments.

Table 3-6. Summary of King County Water Quality Monitoring Programs

Program	Media and Locations	Parameters	Methods	Sampling Frequency	Program Purpose	Duration
Ambient Monitoring						
Marine monitoring	Water and sediments in areas of Puget Sound away from outfalls and CSOs; shellfish and algae ifrom Puget Sound beaches	Water samples: temp, salinity, clarity, DO, nutrients, chlorophyll, and bacteria Beach sediment: grain size, solids, TOC, metals, and organic compounds Shellfish: lipids, bacteria, metals, and organic compounds Macroalgae samples: metals	Water samples at outfalls: collected at multiple depths, ranging from 1 to 200 m Sediments, shellfish, and algae: from single sites	Water samples *:* monthly Beach sediment*:* annually Shellfish & macroalgae: annually	Voluntary—to assess potential effects to water quality from nonpoint pollution sources and to compare quality against point source data	Ongoing
Major lakes monitoring	Cedar-Sammamish Watershed (WRIA 08) only: Lakes Washington, Sammamish, and Union	Temperature, DO, pH, conductivity, clarity, phosphorus, nitrogen, and fecal coliform; micorcystin is measured at select stations	Samples collected every 5 m from 1 m below the surface to near the lake center bottom and around the shoreline	Biweekly during the growing season; monthly during the rest of the year	Voluntary—to monitor the integrity of the wastewater conveyance system and the condition of lakes	Ongoing
Small lakes monitoring	Volunteers monitor 51 small lakes in King County	Precipitation, lake level, temperature, Secchi depth, phosphorus, nitrogen, chlorophyl-a, phytoplankton	Single-point and vertical profiles	Rainfall & lake level: daily Temperature & Secchi depth: weekly Other parameters: every 2 weeks April to October	Voluntary—to characterize and identify trends in water quality	Ongoing

Table 3-6. Summary of King County Water Quality Monitoring Programs

Program	Media and Locations	Parameters	Methods	Sampling Frequency	Program Purpose	Duration
Rivers and streams monitoring	Rivers and streams of both watersheds; emphasis on those that cross wastewater conveyance lines or that could be a source of pollution	Baseflow and storm samples: turbidity, TSS, pH, temperature, conductivity, DO, nutrients, ammonia, bacteria Storm samples: trace metals Sediment quality at selected stations	Various	Monthly sampling under baseflow conditions Three to six times per year at mouth of streams under storm conditions	Voluntary—to monitor the integrity of the wastewater conveyance system and the condition of streams and rivers	Ongoing
Swimming beach monitoring	Cedar-Sammamish Watershed: Lake Washington, Lake Sammamish, and Green Lake	Bacteria		Summer	Voluntary—to evaluate human health risks and necessity for beach closures	Ongoing
Benthic macroinvertebrate monitoring	Wade-able stream sub-basins (Intensive studies also being done under SWAMP and G-DWQA.)	Size and distribution of aquatic macroinvertebrate populations	Surber sampling	Yearly	Voluntary—to establish a baseline for identifying long-term trends	Ongoing
Wastewater Plant Outfall Monitoring						
Marine wastewater plant outfall water column and beach monitoring	Water in Puget Sound near treatment plant outfalls and the Denny Way CSO; sediment, shellfish and algae at beaches near outfalls	Same parameters as in the marine ambient monitoring program	Water samples at outfalls: collected at multiple depths, ranging from 1 to 150 m	Water samples: monthly Beach sediment: annually Shellfish & macroalgae: annually	Voluntary—to assess potential effects to water quality from wastewater discharges	Ongoing
Marine NPDES sediment monitoring	Sediments in Puget Sound near treatment plant outfalls and the Denny Way CSO	Sediment samples at outfalls: grain size, solids, sulfides, ammonia-nitrogen, oil & grease, TOC, metals, organic compounds, and (at South and West Point) benthic infauna	Sediment samples in a grid pattern as defined in the SAP approved by Ecoloogy	Sediment samples at outfalls once per permit cycle	NPDES permit requirement	Ongoing

Table 3-6. Summary of King County Water Quality Monitoring Programs

Program	Media and Locations	Parameters	Methods	Sampling Frequency	Program Purpose	Duration
Special Studies						
Sammamish-Washington Analysis and Modeling Project (SWAMP)	Water and sediments in major lakes—and their inflowing streams	Broad spectrum of water quantity and quality, sediment quality, biological, and physical parameters	Various		Voluntary—to develop a computer model of the watershed	Complete by 2005
Sediment Study	Lakes Washington, Sammamish, and Union	Toxic chemicals & benthic community structure	Grab samples	Lake Sammamish in 1999; Lake Washington in 2000; Lake Union in 2001	Voluntary—to develop a baseline characterization	Completed in 2001; report issued in 2004
Ecological and Human Health Risk Assessment	Water bodies in Cedar-Sammamish watershed	Existing water, sediment, and tissue data	Various, using a tiered approach	Using existing data from other sampling efforts	Voluntary—to assess ecological and human health risk associated with exposure to chemicals of concern	Complete by 2005
Green-Duwamish Water Quality Assessment (G-DWQA)	Water in Green and Duwamish Rivers—and their inflowing rivers and streams	Broad spectrum of water quantity and quality, biological, and physical parameters	Various	Intensive	Voluntary—to develop models, evaluate BMPs, prepare risk assessments	Complete in 2006
Storm Impact Water Quality Monitoring	Water in Green and Duwamish Rivers—and their inflowing rivers and streams—under storm flow conditions	Broad spectrum of water quantity and quality, sediment quality, biological, and physical parameters	Various	Intensive	Voluntary—to evaluate conditions and to support modeling and WRIA planning	Completed in 2003; report issued in 2004
Loadings Calculations	Water in Green and Duwamish Rivers—and their inflowing rivers and streams	Broad spectrum of water quantity and quality, sediment quality, biological, and physical parameters	Estimates based on water quality data and on literature reviews for land use classifications		Voluntary	Report will be issued in 2005

Table 3-6. Summary of King County Water Quality Monitoring Programs

Program	Media and Locations	Parameters	Methods	Sampling Frequency	Program Purpose	Duration
Temperature and DO Studies	Water in Green and Duwamish Rivers—and their inflowing rivers and streams	Daily fluctuations in temperature and DO, especially in the summer	Continuously recording data loggers	Intensive	Voluntary—to evaluate conditions and to support modeling and WRIA planning	Completed in 2003; temperature report issued in 2004; DO report to be issued in 2005
Microbial Source-Tracking Study	Green River and its tributaries	Land uses and bacterial sources associated with bacterial populations		Intensive	Voluntary—to assist in setting and measuring TMDLs	Completed in 2004; report will be issued in 2005
Brightwater Outfall Studies (wastewater capital project)	Water, sediment, & eelgrass for the proposed Brightwater outfall site Upland soils at outfall Portal 19	Water quality: temperature, salinity, DO, nutrients, and fluoresence Sediments: borings for chemicals Upland soils: total petroleum hydrocarbons, lead, and volatiles	Water column samples and continuous buoy readings Borings Soil samples Eel grass diver survey	Intensive	Voluntary--to support the design of the Brightwater Outfall	Complete in 2010
Brightwater Surface Water Characterization (wastewater capital project)	Water samples of surface runoff from proposed treatment plant site and Little Bear Creek upstream and downstream of site.	Temperature, pH, DO, specific conductance, alkalinity, BOD, total dissolved solids,TSS, and turbidity	Auto-samplers	Intensive	Voluntary—to support permitting of the Brightwater plant	Completed in 2004; report will be issued in 2005
Norfolk post-remediation sediment monitoring (wastewater capital project)	Sediment near the Norfolk CSO on the Duwamish River	Chemicals	Sediment samples per approved SAP	Intensive	Regulatory—under a 1991 Consent Decree	Completed in 2004

Table 3-6. Summary of King County Water Quality Monitoring Programs

Program	Media and Locations	Parameters	Methods	Sampling Frequency	Program Purpose	Duration
Denny Way/Lake Union pre-remediation sediment monitoring (wastewater capital project)	Sediment near the Denny Way and Lake Union CSOs	Benthic communities	Sediment samples per approved SAP	Intensive	Regulatory—under a NOAA Fisheries Section 7 ESA consultation	Completed in 2004
Diagonal/Duwamish post-remediation sediment monitoring (wastewater capital project)	Sediments near the Seattle Diagonal storm drain (includes City and County CSO) and the County's Duwamish CSO	Sediment chemistry, turbidity, cap surveys	Sediment samples per approved SAP	Intensive	Regulatory—under an EPA/Ecology Order	Through 2013

BOD = biochemical oxygen demand; DO = dissolved oxygen; TOC = total organic carbon; TSS = total suspended solids; SAP = sampling and analysis plan.

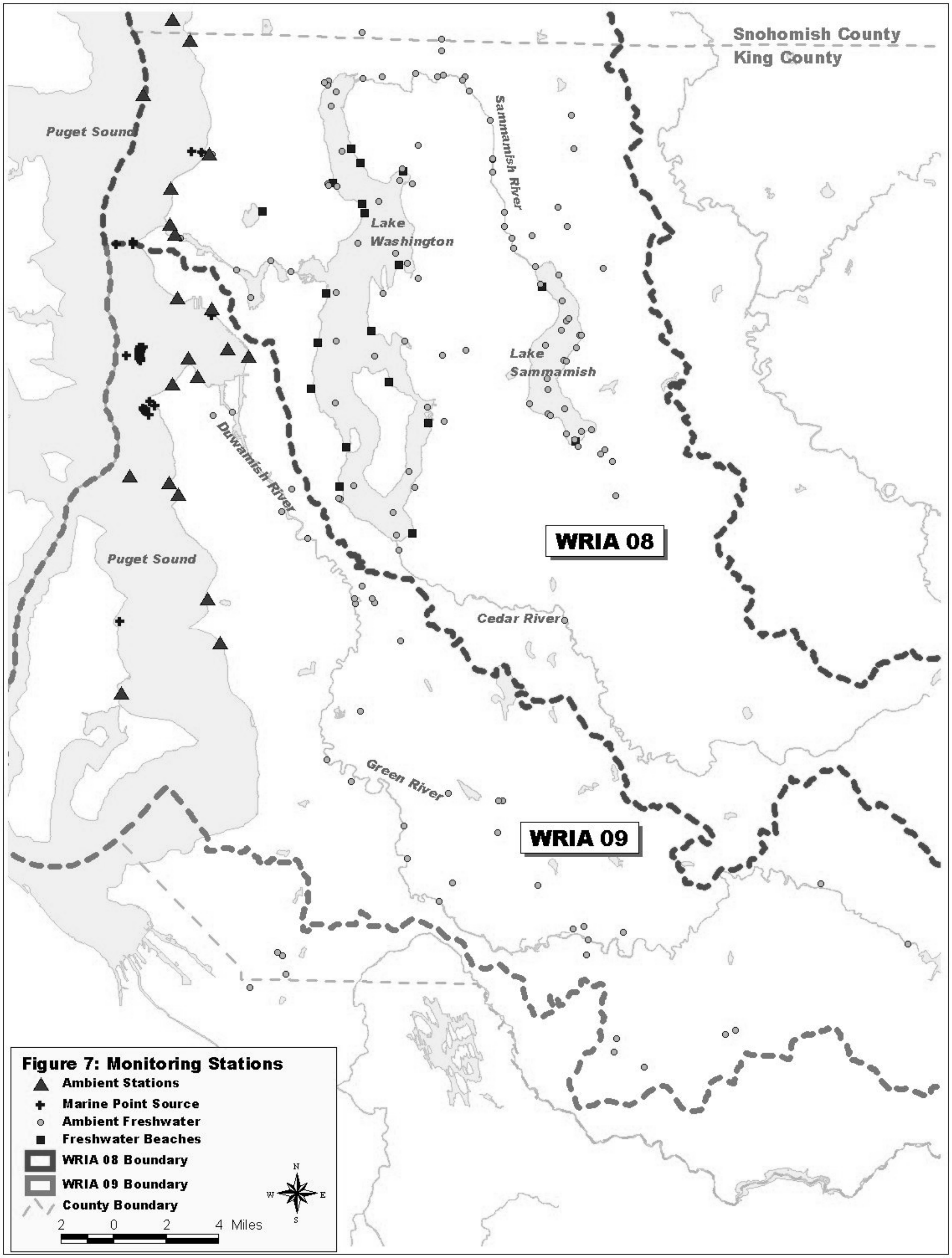

Figure 3-1. King County Monitoring Stations

Marine Ambient Monitoring

Marine ambient monitoring is conducted in areas away from the influence of outfalls or other point source discharges to provide valuable background and comparison data. The program includes water and sediment monitoring as well as shellfish and macroalgae monitoring at selected beaches. Water column monitoring is an important component of the marine monitoring program and is structured to detect natural seasonal variations in the water column and to identify changes influenced by human activities. Temperature and salinity influence the amount of water column stratification, which in turn can influence the amount of pollutants trapped within the water column. Sediment monitoring is included in the marine monitoring program because many pollutants tend to settle onto bottom sediments. At sufficient concentrations, these pollutants may be harmful to organisms that live in or on the sediments (benthic organisms) and may then also accumulate up through the food chain.

Benthic Macroinvertebrate Monitoring

One of the ways to assess the health of a water body is to compare the resident plants and animals to those in a similar water body that is known to be healthy. If the plants and animals are the same types and proportions and of similar number and density, it can be inferred that the studied water body is also healthy. The primary purpose of benthic macroinvertebrate monitoring program is to characterize the size and distribution of aquatic sediment-dwelling macroinvertebrate (insect) populations in King County watersheds. These data collected over time in the ambient monitoring programs will be used to detect any long-term population trends. Additional intense monitoring will attempt to determine the health of macroinvertebrates in wade-able stream sub-basins within the Cedar-Sammamish watershed (WRIA 08) and the Green-Duwamish watershed (WRIA 09). (See “Special Studies” later in this chapter.)

Benthic macroinvertebrates have been monitored under two distinct programs within the County’s Water and Land Resources Division (WLRD). The wastewater-related benthic monitoring program was initiated in the mid-1970s. The primary objective was to monitor streams potentially impacted by wastewater, treated effluent, and the system of pipes and pumps that make up the collection and transfer system. This program was part of the ambient water quality monitoring program that includes lakes and mainstem rivers. In the early- to mid-1990s, a second macroinvertebrate monitoring program began to provide data to evaluate the success of recent basin planning efforts and, when possible, to make specific recommendations for improved watershed management. These two programs were designed to address different, but closely related and complementary, water quality issues. These programs are now combined in the County’s consolidated freshwater monitoring program.

The objectives of the freshwater streams benthic macroinvertebrate monitoring program are as follows:

- Determine existing aquatic macroinvertebrate conditions of wade-able stream sub-basins located within WRIA 08 and WRIA 09
- Identify differences in macroinvertebrate communities in the WRIA 08 and WRIA 09 watershed sub-basins

- Collect data that can be used as a baseline tool for detecting long-term trends in benthic macroinvertebrate communities

Marine Outfall Monitoring

For over 30 years, an extensive outfall monitoring program has been in effect to assess water quality around the marine outfalls for the County's wastewater treatment facilities.

Outfall monitoring is now focused around the County's three secondary wastewater treatment plants, two CSO treatment plants, and the Denny Way CSO (the County's largest CSO). The program consists of water column and sediment monitoring, as well as shellfish and algae monitoring at beaches near the outfalls. A variety of parameters are analyzed, including bacteria, oxygen, and nutrients in the water column and metals and organics in sediments and tissues.

Receiving water monitoring at the outfalls backs up other precautions taken to assure that plant operations are not adversely impacting water quality. For example, effluents are disinfected prior to discharge, continuously monitored for chlorine residual levels, and then analyzed for bacteria at regular intervals as verification that the treatment process is effective.

Sediment monitoring at the outfalls is required under the County's NPDES permits. Ecology and the County are working to reach agreement on a scope of work for sampling design for the next phase of sediment monitoring activities. This will be finalized in the Sampling and Analysis Plan that will be prepared for sampling at each treatment plant outfall.

Beach (intertidal) areas that are in the vicinity of the treatment facility outfalls are also monitored for a variety of parameters to assess whether discharges may be affecting beach areas. Shellfish (butter clams), sediments, and macroalgae samples are collected as part of the beach assessment.

Special Studies

When ambient monitoring suggests the early stages of degrading water quality or when decisions must be made based on scientific information, King County initiates special studies to understand the situation and to project outcomes of different actions. The information from the ongoing monitoring programs often must be supplemented with information from more intense and focused sampling and/or greater analytical precision. These special studies are usually intensive in scope, but limited in time. Currently, there are two major projects—the Green-Duwamish Water Quality Assessment (G-DWQA) and the Sammamish-Washington Analysis and Modeling Project (SWAMP). Several smaller projects under way. Monitoring projects for the Marine Outfall Siting Study (MOSS) to assist in siting the new Brightwater Treatment System marine outfall were completed in 2003. There are current ongoing special studies to support water quality monitoring and to assist in the diffuser design prior to Brightwater outfall construction.

A summary of these studies is shown in Table 3-6; a map of sampling locations is included as Figure 3-1. (Both the table and figure are shown earlier in this chapter.) The table and map also provide information on ongoing monitoring programs, described earlier in this chapter. The details of these complex projects can be found at the County Web sites listed in Appendix B.

Green-Duwamish Water Quality Assessment

The primary goal of the Green-Duwamish Water Quality Assessment is to develop analytical tools for evaluating current and future water quality issues in the Green-Duwamish watershed.[2] It is scheduled to be complete in 2006. The project will provide water quality information to a variety of clients internal and external to King County Department of Natural Resources and Parks (DNRP) by collecting water quality information, developing a watershed model, and using the model to explore resource management options. The project will also assist wastewater capital planning, including the CSO program and the Habitat Conservation Plan (HCP). Specifically, the project will accomplish the following:

- Assess existing and projected water quality conditions for selected parameters, and assess the efficacy of best management practices for achieving Washington State Water Quality Standards in the Green-Duwamish watershed
- Coordinate with Ecology in order to provide technical information for Ecology's TMDL development for stakeholders to use to achieve the most cost-effective improvement in water quality in the watershed
- Assess parameters of interest for King County WTD
- Provide information to support the WTD's HCP and WRIA 09 salmon conservation planning efforts, including information on water quality as a factor of decline for salmonids

Important components of the G-DWQA—storm impact water quality monitoring, loadings and land use analysis, microbial source-tracking, and temperature and DO studies—are described in the following sections.

Storm Impact Water Quality Monitoring

An intensive monitoring program was developed for the G-DWQA to achieve the following objectives:

- Measure instream water quality parameter concentrations in different geographic areas of the watershed throughout the year, including mouths of major tributaries and boundary conditions of the Green River mainstem
- Measure instream water quality parameter concentrations resulting from different land use/land cover types within the stream drainage area

[2] http://dnr.metrokc.gov/wlr/watersheds/green/water-quality-assessment.htm

- Measure in-stream water quality parameter concentrations as a function of the rise, peak, and fall of the corresponding stream hydrograph to determine peak concentrations and variability within a storm-influenced flow
- Collect sufficient data to allow development and calibration of water quality models for the Green River watershed

The program was initiated in 2001 and completed in December 2003. Both storm-influenced and baseflow samples were collected from 17 stations distributed throughout the Green-Duwamish watershed. Some of these stations overlap with the ambient stations monitored in the past in order to provide historical continuity. A water quality report for 2001–2002 was completed 2004 and is available on the Web.[3]

Loadings Calculations and Land Use Analysis

Total loadings will be calculated for the water quality parameters monitored in the program described above. Loading estimates will be established either on an annual basis or on a storm basis. The loading estimates will be based on water quality data generated for this project and on a literature review of loading estimates for the identified land use/land cover classifications. A report on the loading estimates will be completed in 2005.

Temperature and Dissolved Oxygen Studies

To supplement the information collected in the freshwater ambient monitoring programs, an intense temperature and DO sampling program was implemented under the G-DWQA. Both programs use continuously recording data loggers to characterize the daily fluctuations in temperature and DO. The final report on temperature was completed in June 2004; the DO report will be completed in 2005.

Microbial Source-Tracking Study (G-D WQA)

A preliminary review of a small portion of Green-Duwamish water quality data collected during storm events in 2001 and 2002 generally shows that loadings and concentrations of fecal coliform, *E. coli,* and *Enterococcus* increase and decrease with storm flows. This result suggests that bacterial concentrations and loadings are related to precipitation and flows. However, because no clear quantitative relationship between flow-related variables and bacterial concentrations has been established to date, other unidentified factors may also be associated with variation in bacterial concentrations in the Green River watershed. Microbial source-tracking (MST) is being used to investigate the relationship between bacterial sources and land use in the Green River and its tributaries.

Land use may be one of the primary factors determining the specific types and sources of bacterial loadings. Land use and cover types may be useful as a surrogate to predict these

[3] http://dnr.metrokc.gov/wlr/watersheds/green/water-quality-assessment.htm

sources. Sources that may be related to land use include agricultural animals (pasture and agricultural land), septic systems (rural residential), pets (suburban areas), and wildlife/birds (forested and rural areas). In order to elucidate these potential relationships, it is necessary to identify the sources of bacteria in the Green River and its tributaries and correlate them to land uses. This goal can be accomplished by MST.

Further, MST can be used to assist in setting and evaluating progress in achieving TMDLs for fecal coliform in the mainstem reaches and streams that are on the 303(d) list. Affected creeks include Newaukum, Springbrook, and Soos Creeks. Finally, an improved understanding of the relevance of bacterial concentrations to human health and ecological conditions in the watershed is needed. The present MST study will collect information on bacterial sources and land uses associated with bacterial populations. This baseline information may be used to focus future studies to address the human health and ecological implications.

Sampling began in January 2003 and was completed in May 2004. The final report will be issued in mid-2005.

Sammamish-Washington Analysis and Modeling Project

The Sammamish-Washington Analysis and Modeling Project (SWAMP) is a coordinated water quantity and quality monitoring and modeling project that will support future water resource decisions for King County's fresh waters in the Cedar-Sammamish watershed. The overall objectives of SWAMP are as follows:

- Identify risks to aquatic life (including threatened and endangered species), wildlife, and people under existing conditions
- Project future water body conditions and risks under a variety of possible future land use scenarios
- Provide support to resource management programs including:
  - —Salmon conservation and recovery efforts in the watershed
  - —Ecology's TMDL program
  - —WTD's Habitat Conservation Plan
- Provide an organized database and integrated modeling framework to address water resource issues in the watershed

The major component of this project is development of a series of integrated computer models for Lake Washington, Lake Sammamish, Lake Union, and their inflowing rivers and streams. Coupled with these models will be a broader watershed model that simulates streamflow and water quality based on historical, current, and future land use scenarios in King County watersheds. SWAMP is directly linked and coordinated with current King County water resource monitoring efforts. This project will be completed in 2005.

Two components of SWAMP—the sediment study and the risk assessment—are described in the following sections.

Sediment Study

As part of SWAMP, King County undertook a comprehensive sediment sampling study for Lakes Sammamish, Washington, and Union. The sampling took place in 1999–2001. There were four primary objectives of the study:

- Conduct a baseline sediment quality evaluation including both chemical and biological testing
- Evaluate the relative distribution of potential contaminants of concern
- Evaluate sediment toxicity
- Evaluate benthic community structure and compare these data with sediment toxicity testing

The report on the study was completed in 2004.

Risk Assessment

As part of SWAMP, King County DNRP is in the process of conducting an Ecological and Human Health Risk Assessment. The risk assessment (RA) is expected to be completed in 2005. It consists of three tiers. The first tier consists of a general ecological and human health screening of all available existing water, sediment, and tissue data. The screen involves comparing chemical data to effect thresholds, below which adverse effects (risks) are not anticipated. The results of this part of the RA provide a means to focus efforts on specific areas and chemicals that are of greatest concern.

Tier 1 will result in identification of chemical-specific concerns in individual water bodies. Tier 2 includes a spatial evaluation of the chemicals identified in Tier 1 as posing possible risk, in addition to a more detailed assessment of exposure. A human use survey was conducted in the study area to provide more realistic exposure estimates for the human health component of the RA. The survey identified areas where the greatest recreational use (fishing, swimming, beach play) and therefore the greatest exposure to chemicals of concern occur.

For Tier 3, probabilistic risk assessment techniques will be used to further evaluate any potential risk identified in Tier 2. Probabilistic assessments use distributions of species sensitivity combined with distribution of exposure concentrations to better describe the likelihood of exceeding an effects threshold, and thus risk of adverse effects. Because of data availability, probabilistic techniques may be used only for the aquatic and wildlife components of the RA. The results of Tier 3 will be combined with additional physical and biological data to further evaluate potential risk. This “line of evidence approach” will be used to evaluate additional data and provide a more watershed-based approach to the overall RA. The line of evidence assessment will include an evaluation of a number of ecological indices, including the benthic index of biotic integrity (B-IBI), water quality index, sediment quality index, habitat index, and fish index. In addition, toxicity test data will also be included in the line of evidence assessment. These data will be presented spatially using a geographic information system format.

Future work will include an assessment of potential risk for a select group of stressors. This part of the assessment will use data generated by the water quality and quantity models being developed as part of SWAMP.

Wastewater Capital Project Monitoring

Monitoring is done in support of capital project siting, permitting and construction. Usually the monitoring involves pre-construction baseline characterization followed by post-construction monitoring to identify project effectiveness and continued integrity.

Brightwater Outfall Studies

Studies for the Brightwater marine outfall began in October 1998 (under the former program title Marine Outfall Siting Study) to assist with siting and design of a marine outfall for the new Brightwater Treatment Plant. The sampling program included the following major study components: oceanography, submarine geophysics, water column sampling, beach water quality sampling, sediment sampling, and biological surveys.

The *Final Draft Eelgrass Restoration and Biological Resources Implementation Workplan* was prepared in 2004. This plan provides details for the biological resource mitigation plans for the Brightwater marine outfall, including restoration activities that will return intertidal and shallow subtidal habitats to their pre-construction conditions. The workplan includes several innovative approaches to eelgrass restoration, including salvaging and propagating eelgrass prior to construction. A combination of eelgrass monitoring methods will be employed three times prior to construction and will be used five times following construction. The first pre-construction side-scan sonar, underwater video, and SCUBA diver eelgrass surveys were also completed in 2004.

Additional Brightwater work completed in 2004 included sampling and analysis of surface sediments along the marine outfall alignment to verify the suitability of sediments trenched during outfall construction for disposal at a Puget Sound Dredged Disposal Analysis (PSDDA) open-water facility. This additional sediment characterization was required by the PSDDA agencies as a result of a fuel spill that occurred in January 2004 at the bulk fuel terminal located at Point Wells.

Brightwater Surface Water—Initial Characterization

The primary goal of the Brightwater Route 9 Monitoring project is to provide water quality and quantity information in the vicinity of the preferred Brightwater Route 9 treatment plant site. The scope of work includes water quality and hydrologic monitoring for the following objectives:

- Provide data on parameters that affect fish species in the local basin
- Establish baseline data on the current quality of site runoff from the preferred Brightwater Route 9 treatment plant site

- Provide information that will be used in the future for comparison to Brightwater construction and operating conditions in the local basin

In order to evaluate the effects of the proposed Route 9 site development, measurements were taken to identify the quality of waters leaving the site and to characterize Little Bear Creek upstream and downstream of the site. Water quality parameters analyzed for this project include alkalinity, biochemical oxygen demand (BOD), total dissolved solids, total suspended solids, turbidity, temperature, pH, DO, and specific conductance.

Sampling began in October 2003 in an attempt to capture low-flow conditions prior to the start of the normal wet season (typically October through May). Sampling continued through December 2004.

Denny Way/Lake Union CSO Control Project: Pre-Remediation Sediment Characterization Study

The Denny Way/Lake Union CSO Control Project is a joint effort between King County's Wastewater Treatment Division and Seattle Public Utilities to control City and County CSO discharges into Lake Union and the Denny Way CSO into Elliott Bay. In 2004, monitoring was completed to characterize the sediments and to design the remediation that will be undertaken when the CSO control project is completed in 2005.

Norfolk CSO Sediment: Post-Remediation Monitoring

Sediment remediation at the Norfolk CSO site was undertaken in response to a 1991 Consent Decree, which defined the terms of a natural resources damage agreement between King County, the City of Seattle, and federal, state, and tribal natural resources trustees. The Norfolk CSO site was chosen by the oversight group—the Elliott Bay/Duwamish Restoration Program (EBDRP)—as one of four sites prioritized for potential sediment remediation.

Chemicals of concern at the site included mercury, 1,4-dichlorobenzene, bis (2-ethylhexyl) phthalate, and PCBs. Site remediation was completed in late March 1999. Under the site hydraulic permit, issued by the Washington State Department of Fish and Wildlife, a five-year post-remediation monitoring program was implemented to assess cap stability and possible recontamination over time. The monitoring was completed in 2004. Results indicate that little recontamination of the cap is occurring from the CSO and nearby stormwater outfalls. This work completes the project and demonstrates that current CSO discharges may not be depositing sediment contaminants at levels of concern.

Diagonal/Duwamish Stormdrain and CSO Dredging and Capping: Post-Remediation Monitoring

Remediation of the areas off of Seattle's Diagonal storm drain and the County's Duwamish Pump Station CSO was identified as an early action project under the response to the Superfund listing of the Lower Duwamish Waterway. The Diagonal storm drain is a shared outfall for City stormwater and CSO discharges, the past County Hanford No. 1 CSO discharges, and current

County discharges from Hanford at the Rainier, Bayview North, and Bayview South CSOs. The remediation is another joint project between the County, City of Seattle, and EBDRP.

The remediation alternative chosen was dredging of the contaminated sediments and capping with clean sediments. To support the dredging process, several monitoring efforts are under way or planned. Characterization of the sediments has been done to satisfy requirements for safe disposal. Sampling is being conducted to address site conditions in the Duwamish River before, during, and after the dredging. The purpose of this sampling is to monitor for any spread of the contaminated sediments, to monitor for compliance with water quality standards during dredging, and to document final improvement over original conditions. Water column samples taken during dredging showed that the chemicals of concern (mercury and PCBs) were found in low concentrations, below existing Water Quality Standards.

The capping was completed in 2004. A ten-year post-remediation monitoring program was started to document cap stability and any chemical recontamination of the cap surface. Initial monitoring results indicate that some contamination had been spread offsite of the original 7-acre cleanup area during capping. Follow-up action is planned for early 2005 to address the problem.

Other Regional Water Quality Programs

Other entities within King County conduct monitoring and water quality protection programs. King County makes an effort to keep informed of this work, coordinate efforts for complementary results, and negotiate joint work where interests overlap. Programs are as follows:

- Ecology runs both a sediment and water monitoring program with sites located within King County. None of King County's stations overlap with Ecology's stations. Both agencies review the other’s data to gain a more comprehensive picture of water quality.
- The Washington State Department of Fish and Wildlife (WDFW) collect fish samples within King County waters and analyze them for chemical contaminants. King County reviews and uses these data as appropriate. King County worked cooperatively with the University of Washington and Public Health–Seattle & King County to sample, analyze, and interpret data for Lakes Washington and Sammamish. The effort resulted in a fish consumption advisory for Lake Washington.
- The U.S. Geological Survey (USGS) performed stream monitoring for the presence or absence of pesticides. King County has built upon this program in a cooperative effort.
- The USGS conducted water quality sampling within the Green River watershed. This data will be incorporated into the G-D WQA model development as appropriate.
- The University of Washington (UW) is working jointly with King County on several projects supplementing the SWAMP project. The UW School of Fisheries is working on the ecosystem dynamics component and the bioaccumulation study for the model. The UW Department of Civil and Environmental Engineering is working on the lake-dynamics and biological processes modeling efforts and the mid-trophic model.

- UW is working jointly with King County on characterization of water quality conditions in the Mill Creek/Mullen Slough basin. Water quality data in Mill Creek/Mullen Slough were identified as a data gap in the model selection report (ftp://dnr.metrokc.gov/hydrodat/GDWQA/); data collected will be used to develop models for the G-DWQA.
- King County, WDFW, Seattle Public Utilities, and the Muckleshoot Tribe are conducting chinook surveys in the main stem of the Cedar River.
- King County in partnership with the City of Kirkland is conducting habitat surveys in the Juanita Creek area.
- The Salmon Watcher Program trains volunteers to observe, count, and identify salmon in streams. King County conducts this work in partnership with Seattle, Bellevue, Redmond, Federal Way, Snohomish County, WDFW, and the Muckleshoot Tribe.
- King County Department of Transportation, Roads Services, conducts water quality and macroinvertebrate sampling at several road crossing sites within the Green-Duwamish River watershed. The sites, parameters, and methods differ from those of the G-DWQA. The G-DWQA is designed to address some of the remaining data gaps.
- The Puget Sound Ambient Monitoring Program is coordinated by the Puget Sound Water Quality Action Team and is a long-term effort to investigate environmental trends and prevent overlaps and duplication in monitoring efforts. King County participates in this program, the only local entity to do so, to ensure that there are no overlaps with other monitoring efforts.
- The Washington State Department of Health collects marine water samples for bacterial analysis (fecal coliform) in King County at two locations on Vashon Island. They also analyze shellfish tissues for Paralytic Shellfish Poisoning (PSP) at these same locations as part of a larger statewide sampling program to protect consumers of shellfish. None of the bacteria stations overlaps with King County stations, and the County does not monitor PSP.
- The National Oceanographic and Atmospheric Agency (NOAA) samples three stations in King County for chemical contaminants in mussels as part of the national Mussel Watch Program. NOAA Fisheries has sampled salmonids in the Duwamish River for evidence of chemical impairment. The County uses this information in its studies.
- The Port of Seattle monitors sediment quality at Port-owned property in King County. There is no overlap with County stations.
- The U.S. Army Corps of Engineers is required to monitor sediment quality during routine maintenance dredging, which often occurs in the Duwamish River. The County uses this information in its projects.
- The City of Seattle monitors sediment quality at some of its CSOs and storm drains. The County uses this information in marine modeling efforts.
- In the spring 2002, Ecology applied for and received a grant from EPA to develop a marine beach monitoring and notification program for the State of Washington, called the BEACH (Beach Environmental Assessment Communication & Health) program. The

program is being implemented collaboratively between Ecology, the Department of Health, counties, and volunteers. In 2004, thirteen King County beaches were monitored weekly during the recreational season for *Enterococcus* bacteria levels and the results posted on the BEACH program Web site.[4]

[4] http://www.doh.wa.gov/ehp/ts/WaterRec/beach/default.htm

Chapter 4

Program Results—State of King County Waters

This chapter summarizes the state of the waters within the wastewater service area of western King County. Monitoring and management performance in 2003 indicates that County efforts continue to make a significant contribution to protecting regional water quality and public health. No needs were identified that are not being addressed, and the wastewater system is achieving its purposes. Continuing vigilance by agencies like King County is recommended as the pressures of urbanization on water quality continue to increase. King County residents will then continue to enjoy the excellent water quality that they value and expect.

Cedar-Sammamish Watershed (WRIA 08)

Water quality in the major lakes of the Cedar-Sammamish watershed—Lake Sammamish, Lake Washington, and Lake Union—continues to be good in 2004. Water quality, as described by the Trophic State Index, has fluctuated between moderate (mesotrophic) and good (oligotrophic) over the last nine years. Lakes Sammamish and Washington were considered good 27 and 64 percent of the time, respectively. Lake Washington has maintained good water quality for the last two years. With the exception of 1995, Lake Union has had moderate quality. Figure 4-1 illustrates the summer average variability in each lake from year to year (1994–2004). Often these year-to-year changes are the result of regional climatic differences such as drought or cooler summer temperatures and appear as similar fluctuations in the lines for all three lakes.

Lake Washington

Water Quality

Lake Washington can be characterized as having good water quality (oligotrophic) in 2004, as shown in Figure 4-2. Water clarity was good (measured as Secchi transparency), phosphorus values were moderate to low, and algal levels (measured as chlorophyll-*a*) were moderate to low, with peak algal growth occurring in early summer and late fall. The wastewater system goals of reduced nutrient loading and subsequent reduction in algal biomass were achieved, and improved stormwater management practices have prevented increases in nutrient enrichment that often result from the type of extensive development that has been occurring in the area.

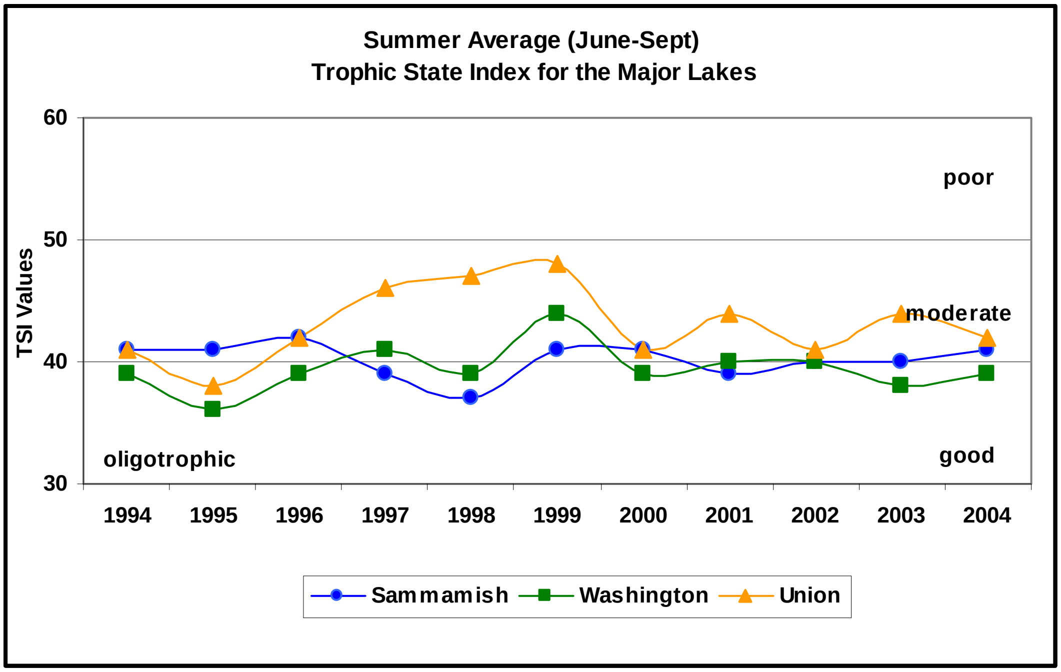

Figure 4-1. Average Summer Trophic State Index for Major Lakes in the Cedar-Sammamish Watershed—1994 through 2004

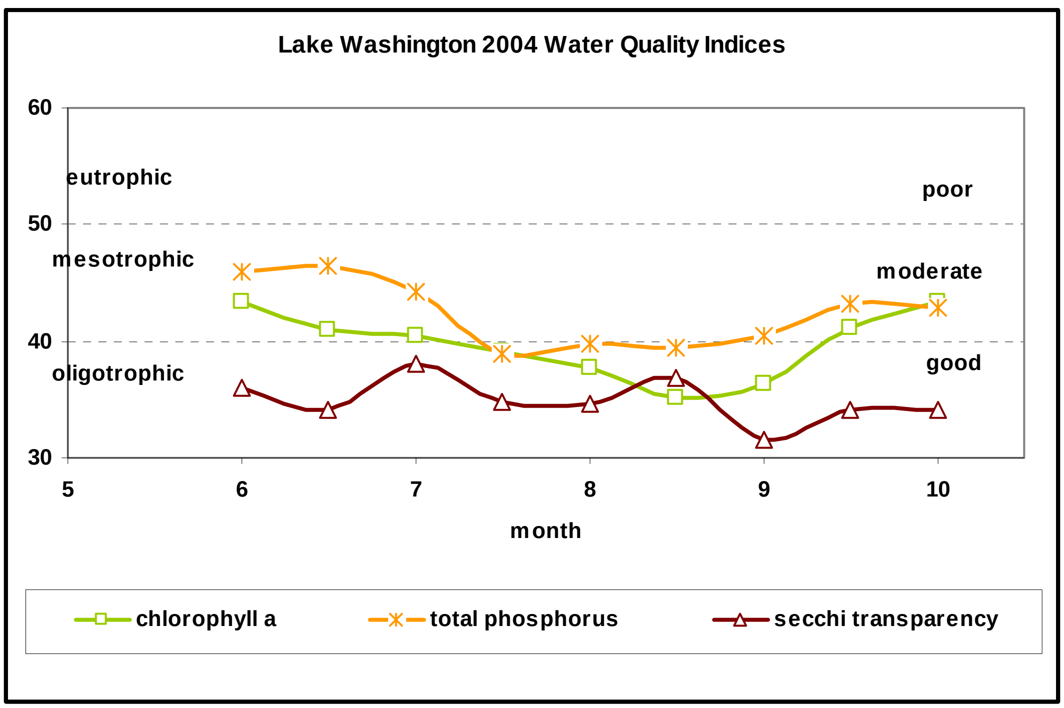

Figure 4-2. 2004 Water Quality Indices for Lake Washington

Sediment Quality

In 1999 through 2001, sediment samples were collected from 26 sites throughout Lake Washington and analyzed for chemistry, toxicity, and benthic community structure. A preliminary analysis of these data was conducted using a modified Sediment Quality Triad (SQT) approach. The SQT was developed as a method for assessing sediment quality when sediment chemistry, toxicity, and benthic data are available at a site; all three data types are combined to evaluate the level of adverse impact under a weight-of-evidence approach.

A number of metals and organic compounds were detected above sediment quality guidelines (non-regulatory, professional judgment-based measures). Toxicity was observed at 9 of the 26 sites. Benthic data suggest that some sites do not support a healthy benthic community. Using the SQT approach, sampling locations were classified as having high, moderate, low, and no impact. Nine of the 26 sites were considered to have high or moderate impact, while the remaining 17 sites were considered to have low or no impact.

In 2004, a detailed SQT assessment was completed for all three of the major lakes (Washington, Sammamish, and Union). The results provide County scientists with the information necessary to identify areas of concern and assist in identification of future sampling programs. The final report will be available in early 2005.

Lake Sammamish

Water Quality

Overall conditions in Lake Sammamish were moderate and nutrient concentrations and subsequent algal biomass continued to be in the moderate range in 2004, as shown in Figure 4-3. Table 4-1 shows that the goal for clarity was met. The average summer algal volumes (measured as chlorophyll-*a*) and annual phosphorus concentrations were slightly higher than the goals. Phosphorus concentrations were high in early summer, declined through the summer, and showed another smaller peak in the fall. Algal volumes followed the same pattern as phosphorus. (Phosphorous concentration is a primary factor that induces algal growth.)

Table 4-1. Water Quality Goals and 2004 Values for Lake Sammamish

	Mean Annual Volume Weighted Total Phosphorus (µg/L) Calendar Year	Summer Chlorophyll-*a* (mg/m^3) June–September	Summer Secchi Depth (meters) June–September
Goals[a]	22.0	≤ 2.8	≥ 4.0
2004 Values	23.0	3.3	5.2

[a] As defined in the *Lake Sammamish Management Plan,* 1989.

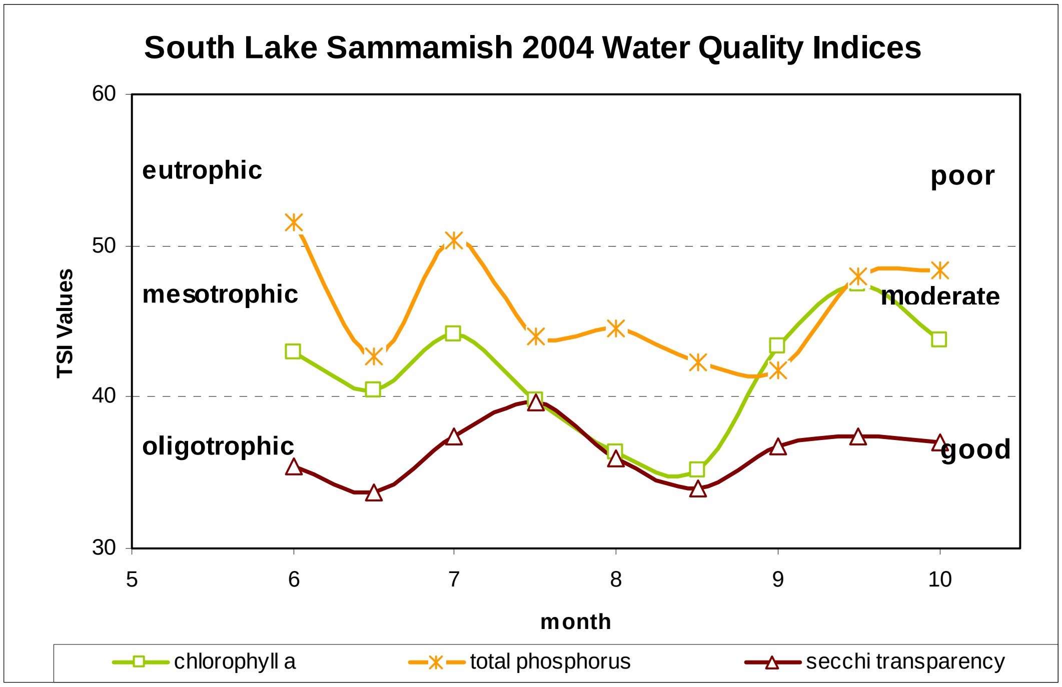

Figure 4-3. 2004 Water Quality Indices for Lake Sammamish

Sediment Quality

The highest levels of sediment-associated contaminants in Lake Sammamish were found in the vicinity of stormwater discharges and at deep lake locations. A number of metals and organic compounds were found to exceed the sediment guidelines throughout the lake; however, toxicity test results suggest that sediment-associated contaminants are creating adverse impacts in only a few areas.

Application of the SQT approach (see Lake Washington "Sediment Quality" section above) was completed for Lake Sammamish in 2004. The final report will be available in early 2005.

Lake Union

Water Quality

Lake Union has historically been characterized as mesotrophic (moderate water quality) with fluctuations in some years to oligotrophic (good water quality) and eutrophic (poor water quality). Measurements taken over the summer 2004 characterize Lake Union as having moderate water quality overall. Figure 4-4 shows that algal biomass declined throughout the summer, increasing again to a lesser degree by September. Water clarity, in general, increased when algal biomass was low and decreased when the biomass was high. Phosphorus concentrations were high at the beginning of June and then were in the moderate range through October.

Historically, thermal stratification has caused oxygen deprivation (anoxic conditions) in the lake bottom waters. The optimal oxygen concentration for salmonids is between 6 and 8 mg/L. Dissolved oxygen (DO) concentrations become critical for fish survival at 4.25 mg/L and lethal below 2.0 mg/L. Temperatures for salmonids are optimal between 12 and 16°C, critical around 18°C, and lethal at 23°C. By June 22, DO concentrations at depths in the lake greater than 11 meters were less than 5 mg/L and temperatures in the top 5 meters were 18°C or greater. By July 19, DO concentrations at depths below 10 meters were less than 5 mg/L and temperatures in the top 9 meters of the lake were at 18°C or greater, substantially reducing available habitat for salmonids.

When DO concentrations drop below 2 mg/L at the sediment interface, phosphorus that is bound with iron in the sediment dissolves and is released into the water column. This process was evident in Lake Union as the summer stratification progressed. Total phosphorus concentrations at 14 meters increased from 13 µg/L on May 4 to 761 µg/L on September 7. While the lake remains stratified, the increased phosphorus concentrations in the bottom waters do not mix vertically and therefore do not influence the phosphorus concentrations lake-wide until the water column mixes in late fall or early winter.

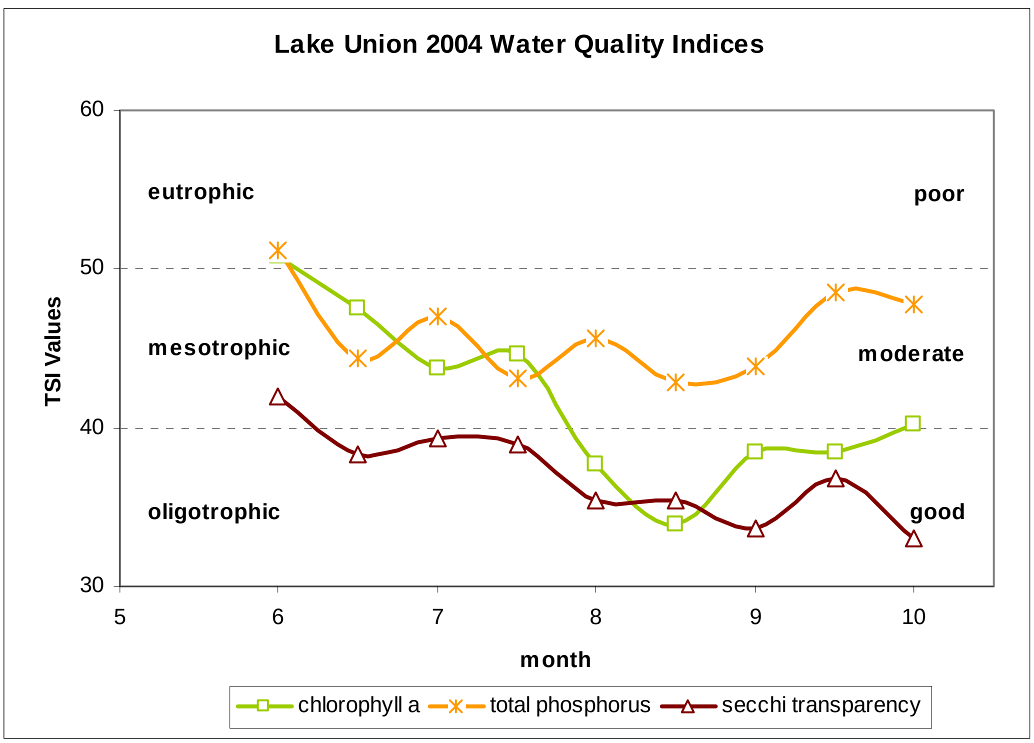

Figure 4-4. 2004 Water Quality Indices for Lake Union

Sediment Quality

In 1999 through 2001, sediment samples were collected from 16 sites throughout Lake Union and analyzed for chemistry, toxicity, and benthic community structure. A number of metals and organic compounds were detected above sediment quality guidelines. Toxicity was observed at some locations. Benthic data suggest that some sites do not support a healthy benthic community.

Application of the SQT approach (see Lake Washington “Sediment Quality”section above) was completed for Lake Union in 2004. The final report will be available in early 2005.

Small Lakes

In 2004, volunteers sampled 51 lakes in King County. Results of this sampling are not yet available. As of 2003, many lakes are maintaining their quality. Several lakes appear to be making gains in water quality, as demonstrated by decreasing Trophic State Indexes. The 2004 results will be posted on the Web site[1] and reported in the annual *Volunteer Lake Monitoring Report.*

Rivers and Streams

Thirty-six sites on two rivers and 22 streams have been sampled monthly in the Cedar-Sammamish watershed (WRIA 08) under base flow and wet weather conditions—some for over 20 years. The two main rivers in the watershed are the Sammamish River and the Cedar River.

Sammamish River

Water Quality

The Sammamish River is listed on the Washington State Department of Ecology's (Ecology's) 1998 303(d) list for exceeding standards for temperature, DO, pH, and fecal coliform. High river temperatures typically result in low DO concentrations because warmer water holds less dissolved gases. Higher temperatures and subsequent lower DO concentrations occur in the summer and early fall when chinook and sockeye salmon are returning to spawn in tributaries. In general, elevated temperature is considered one of the most serious water quality problems, limiting beneficial uses in the river. River temperatures as high as 27°C in late July have been observed, which is far above the lethal limit for salmon. High temperatures can affect reproductive health and survival of all adult fish entering the river. Elevated but sub-lethal temperatures common in June and July can also cause feeding alterations, decreased resistance to disease, and even mortality in juvenile salmon.

[1] http://dnr.metrokc.gov/wlr/waterres/smlakes/reports.htm

Tracking of adult chinook in 1998 and 1999 indicated that salmon use every deep area in the river during migration, likely in an attempt to find cooler water conditions. The most serious temperature problems are located where the warm surface waters of Lake Sammamish feed the river. The relationship between the lake and river suggests that the Sammamish River has historically been warmer than many Northwest rivers in the summer and early fall. However, the historical river channel conditions likely provided significantly more cool-water refuge for salmon than is currently available. The historical channel meandered through a vast wetland complex that dominated much of the corridor, providing greater shade cover, more pools, and greater connection with groundwater and tributaries, all of which contributed to maintaining cooler river temperatures.

To better understand the issue of increased temperature in the Sammamish River, King County has been evaluating the conditions that influence the overall temperature in the river (riparian vegetation conditions, groundwater, and influence of tributary flow) through the Sammamish-Washington Analysis and Modeling Project (SWAMP), which is described in Chapter 3. In addition, computer models are being developed to help identify which potential restoration options would have the greatest influence on decreasing temperature in the river; for example, increased shade, increased groundwater inflow, or provision of a cool-water inflow source.

Sediment Quality

To better characterize the presence of toxic chemicals, King County collected sediment samples in 2001 and 2003 and water samples from 2001 to 2003 in the Sammamish River. Water and sediment samples were analyzed for various chemicals such as pesticides, metals, conventional parameters, and nutrients. In addition to conducting chemical analyses, the County is evaluating sediment samples to determine the overall health of the populations of aquatic organisms living in the riverbed. Evaluating the types and numbers of organisms present in river sediments provides additional information on the overall ecological health of the river. Samples were collected from 10 locations throughout the 13-mile length of the river. Sampling sites were located below major tributaries and in the vicinity of potential sources of pollution.

The comparison of sediment chemistry data with toxicity thresholds indicates that arsenic and nickel are at slightly elevated concentrations (above some thresholds) at a few stations. However, the measured maximum concentrations are low enough that the metals are suspected to be of natural origin. No other contaminants measured in sediments from the Sammamish River were detected at concentrations that would pose a risk to aquatic life. A full report of the findings will be published in 2005.

Cedar River

The Cedar River is listed on Ecology's 1998 303(d) list for fecal coliform bacteria. The lower main stem of the Cedar River and major tributaries provide the majority of the spawning habitat for chinook, sockeye, and steelhead, as well as significant spawning and rearing habitat for coho and cutthroat trout. The WRIA 08 Technical Committee identified the following mainstem factors of decline for chinook: access and passage barriers, loss of channel complexity and connectivity, degradation of riparian conditions, altered hydrology and flow, and increased and altered sedimentation. Details of the factors of decline and proposed action alternatives are documented in the *Lake Washington/Cedar/Sammamish Watershed (WRIA 08) Chinook Salmon Conservation Plan (*November 2004*)*.

Small Streams

As part of the County ambient monitoring program, 36 sites on 23 streams and two rivers have been sampled monthly in WRIA 08 under base flow and wet weather conditions.

For this report, the data from October 2003 through September 2004 were used to evaluate the water quality conditions using Ecology's Water Quality Index (WQI), modified slightly to better represent county rivers and streams. No sites in WRIA 08 had a high enough water quality ranking to be considered a low-concern site (Figure 4-5). Eighteen sites were considered in the moderate-concern range. Seventeen sites were considered in the high-concern range.

High-concern ratings were caused at least in part by excessive bacteria levels at 14 of the sites in WRIA 08. Low DO and/or high phosphorus concentrations were also a problem at some of the high-concern sites. Six of the sites with high bacteria counts are in urban areas (Fairweather-0498, Thornton-0434, Juanita-0446 and C446, Sammamish at Kenmore-0450, and McAleer-A432), two are downstream of agricultural activities (North-D474 and Evans-B484), and four are downstream of wetlands (Forbes-0456, Kelsey West Branch-D444, Tibbetts-X630, and Pine Lake Creek-A680). Pets and failing septic systems are the most likely sources of bacteria in the urban areas. Poor livestock management practices can be a potential source of bacteria in agricultural areas. Wildlife and stagnant water conditions can lead to elevated bacteria counts in wetland areas. Phosphorus is found in fecal material, and elevated phosphorus concentrations are often linked to similar sources as bacteria. In addition, elevated phosphorus concentrations are linked to areas with high volumes of stormwater runoff and areas undergoing development.

Five sites were rated high-concern primarily because of low DO concentrations (Fairweather-0498, Issaquah North Fork-A632, Evans-B484, Swamp-0470, and Upper Evans-S484). Low DO concentrations can be associated with low flows, high temperatures (warmer water holds less oxygen), and high levels of organic matter (bacteria use up oxygen in the process of decomposition).

Precipitation was above the historical average during October 2003 through May 2004 and was comparable to the historical average throughout the summer of 2004. The King County hydrologic Web site gives more information about rainfall patterns in the last few years.[2]

[2] http://dnr.metrokc.gov/hydrodat/bbs.htm

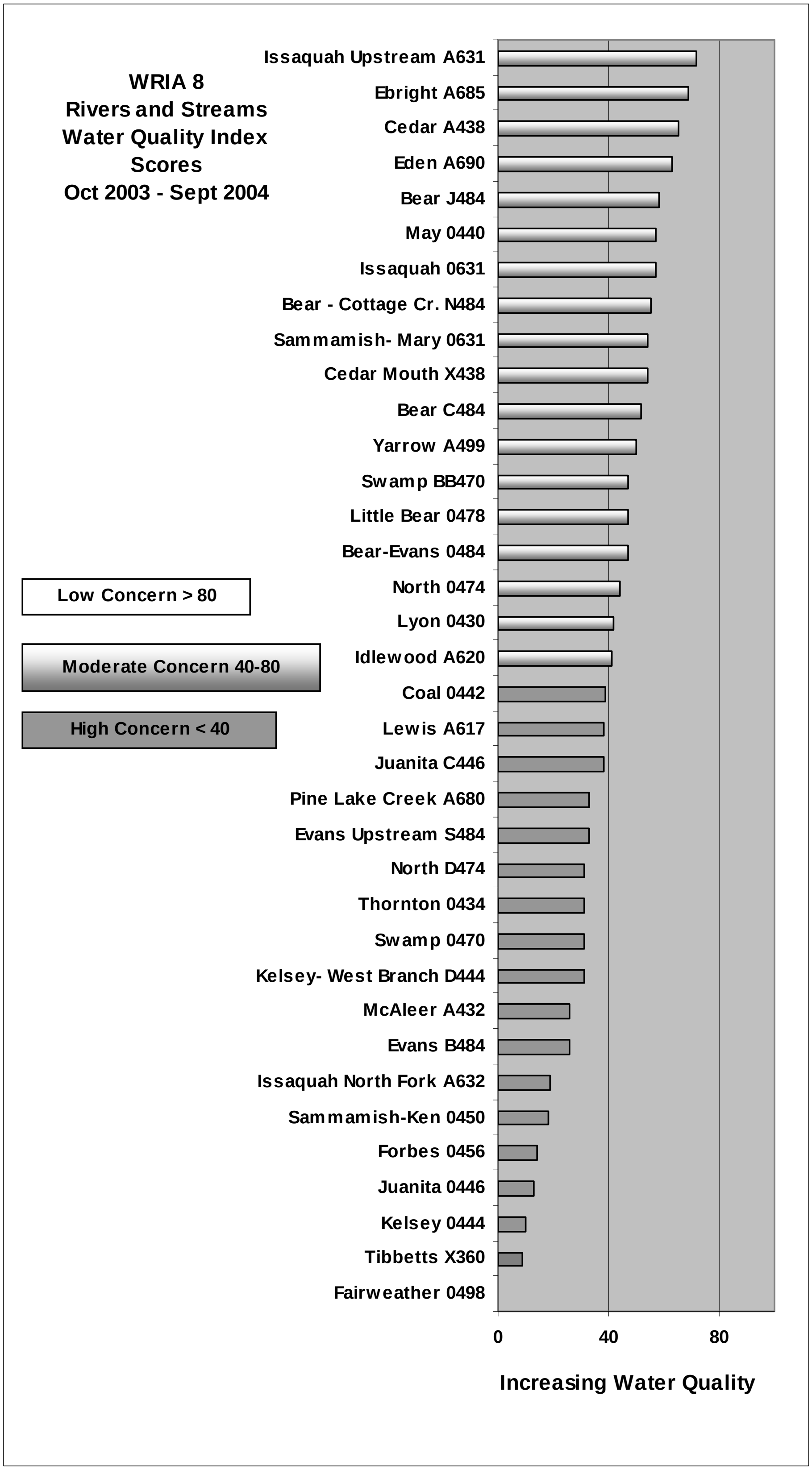

Figure 4-5. WRIA 08 Rivers and Streams Water Quality Index Scores

Stream Sediment Quality Sampling

The stream sediment portion of the Ambient Monitoring Program was updated in 2004. Additional parameters were added to the existing program to better understand the range of contaminants that affect sediment quality. In addition, a two-tiered sampling design was incorporated to allow for the assessment of sediment quality and for the analysis of long-term trends in individual stream basins.

Basin Analysis

Each year, three of the following streams in WRIA 08 will be chosen for a basin analysis: Little Bear, Big Bear, Thornton, Issaquah, McAleer, North, Newaukum, Soos, Springbrook, Mill, Coal (Lake Washington), Forbes, Juanita, Lyon, May, Mercer Slough, Swamp, Lewis, Pine Lake, Eden, Ebright, Tibbetts, Taylor (Cedar River), Covington, Des Moines, Jenkins, Judd, Crisp, and Longfellow.

Long-Term Trend Analysis

Table 4-2 lists the stations that will be sampled annually to analyze long-term trends in sediment quality in small streams in WRIA 08.

Table 4-2. Sampling Station Locations for Long-Term Trend Analysis of Sediment Quality in Small Streams in WRIA 08

Creek	Locator
Little Bear Creek	0478
Big Bear Creek	0484
Thornton Creek	0434
Issaquah Creek	0631
McAleer Creek	0432
North Creek	0474
Newaukum Creek	0322
Soos Creek	A320
Springbrook Creek	0317
Mill Creek	A315

Brightwater—Initial Surface Water Characterization

Water quality measurements are being taken to characterize the quality of waters leaving the proposed site for the Brightwater Treatment Plant as well as to characterize Little Bear Creek upstream and downstream of the site. Auto-samplers are located at each of the monitoring stations. Water quality parameters to be analyzed for this project are conventional parameters (alkalinity, biochemical oxygen demand [BOD], total dissolved solids, total suspended solids, and turbidity) and in-stream parameters (temperature, pH, DO, and specific conductance).

Sampling began in October 2003 in an attempt to capture low-flow conditions prior to the start of the normal wet season (typically October through May). Sampling continued through December 2004. Results will be available in 2005.

Green-Duwamish Watershed (WRIA 09)

An assessment of the current water quality conditions in the Green-Duwamish watershed was compiled in 2000 from water quality reports and from analysis of water quality data collected between 1996 and 1999. Numerous streams in the watershed are listed on Ecology's 1998 303(d) list of water bodies that do not meet Water Quality Standards. These include portions of the Duwamish River, lower Green River, Springbrook Creek, Mill Creek, Mullen Slough, Soos Creek, and Newaukum Creek. Fecal coliform bacteria, DO, and temperature are the most common parameters listed, but there are also isolated listings for pH, metals, and ammonia.

Fecal coliform bacteria typically exceed standards during storm conditions in all of these listed water bodies. DO and temperature typically exceed standards during warmer summer conditions when stream flows are lower. DO and temperature are mostly a problem in the tributaries, but are occasionally a concern in the Green River mainstem.

Small Lakes

In 2004, volunteers sampled 51 lakes in King County. Results of this sampling are not yet available. As of 2003, many lakes are maintaining their quality. Several lakes appear to be making gains in water quality, as demonstrated by decreasing Trophic State Indexes. The 2004 results will be posted on the Web site[3] and reported in the annual *Volunteer Lake Monitoring Report.*

Green and Duwamish Rivers

In general, the water quality is good in the Duwamish Estuary. The risks to organisms that dwell in the water column are minimal; however, there are potential risks to benthic (sediment-dwelling) organisms from several chemicals in the sediments. Risks to the benthic organisms can potentially translate into risks to salmonids via food-chain transfer, reduction in immune system functioning, or reduction in available food. This is an example of why sediment remediation in the Duwamish River is of high priority for the County.

[3] http://dnr.metrokc.gov/wlr/waterres/smlakes/reports.htm

Small Streams

As part of the County ambient monitoring program, 16 sites in six sub-basins and mainstem rivers were sampled monthly in WRIA 09 under baseflow and wet-weather conditions. For this report, freshwater data from October 2003 through September 2004 were used to evaluate the water quality conditions using Ecology's Water Quality Index (WQI), modified slightly to better represent county rivers and streams. Water quality at five sampling sites in Green River and Soos Creek had a high enough water quality ranking to be considered low-concern sites; seven sites were ranked in the moderate-concern range; and two sites, Mill and Springbrook Creeks, were ranked of high concern (Figure 4-6).

The high-concern ratings were caused in part by low DO levels in Mill Creek and Springbrook Creek. High phosphorus concentrations were also a problem at Springbrook Creek, which flows through an urban area. Elevated phosphorus concentrations are linked to areas with high volumes of stormwater runoff and areas undergoing development.

Historical Water Quality Trends and Salmon

The Green-Duwamish Water Quality Assessment (G-DWQA) has completed an analysis of all historical water quality data available for the Green and Duwamish Rivers. Water quality conditions in the Lower Green and Duwamish Rivers have improved from the poor water quality conditions that existed in the 1960s and earlier. This is a result of the reduction of municipal and industrial discharges including the relocation of the South Treatment Plant's outfall from the Lower Green River to Puget Sound.

There has been a trend toward increasing surface water temperatures in most tributaries in the urban and urbanizing areas of the region over the past 20 years, probably attributable to factors such as increased runoff from impervious surfaces and loss of riparian vegetation that can result from development and urbanization.

In studies conducted using continuous monitoring probes along the main stem of the Lower and Middle Green River, temperatures were seen to peak between 23 and 24°C during the summer. In some years, these temperatures could be of concern for adult chinook migrating in August and early September. Water temperatures in some tributaries of the Mill and Springbrook sub-basins have been historically high and are probably of concern for salmonid rearing. Water temperatures in several Soos Creek tributaries during spawning and rearing are also of concern. Analysis of the recently collected baseflow and stormwater sampling data will allow more complete exploration of changes in temperature and their effect on fisheries and other aquatic resources.

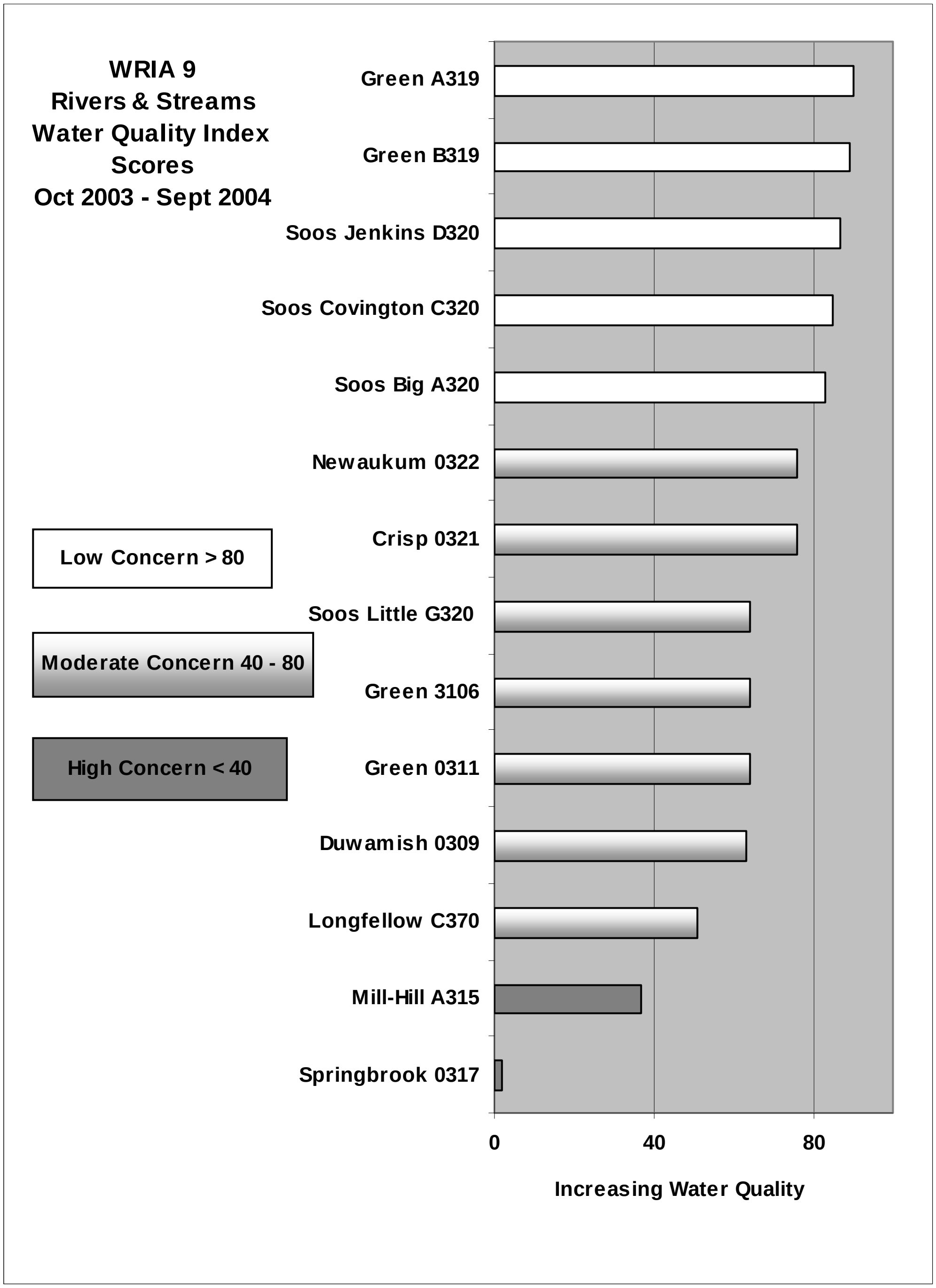

Figure 4-6. WRIA 09 Rivers and Streams Water Quality Index Scores

DO levels are one of the most significant issues for salmonids in the basin. DO levels in the mainstem of the Duwamish and Lower Green Rivers are of concern for salmonid rearing on some occasions. DO levels in the mainstem of the Middle Green River (above RM 24 where most mainstem spawning occurs) are occasionally of concern during incubation. DO for incubation and rearing is a probable factor of decline for salmonids in several tributaries, particularly Springbrook Creek, Mill Creek, Soos Creek, and Newaukum Creek. The most severe documented DO problem is in the Mill Creek basin.

Turbidity and total suspended solids are possible factors of decline in terms of water column impacts for the Duwamish River, Lower Green River, Mill Creek, and Springbrook Creek. Analysis of recent data will shed more light on this issue.

Recent data from King County streams indicate that pH, ammonia, and metals are unlikely to be factors of decline for salmonids. Exceptions include the Mill Creek basin, where ammonia may be a factor of decline, and Springbrook Creek, where metals (cadmium, chromium, copper, mercury, and zinc) may be of concern. Metals may also be of concern in localized areas near stormwater outfalls. This historical information, along with the recent baseflow and stormwater sampling completed in 2003, will be used for modeling of the watershed to predict future conditions and explore ways of reducing water quality impairments.

Microbial Source-Tracking Study (G-D WQA)

The microbial source tracking study collected information on bacterial sources and land uses associated with bacterial populations. Sampling began in January 2003 and was completed in May 2004. A final report on the findings will be issued in mid-2005.

Puget Sound Marine Waters

Only locations sampled in Puget Sound since the adoption of the Regional Wastewater Services Plan (RWSP) in 1999 are discussed because stations change with changing program goals over time. Sampling locations prior to 1999 may be found in the appropriate yearly *Water Quality Status Report for Marine Waters* produced by King County's Department of Natural Resources and Parks, Water and Land Resources Division.

Water Quality

Dissolved Oxygen

DO concentrations in Puget Sound are generally above 7.0 mg/L in the late winter and early summer months at all depths and locations sampled. Throughout the year, DO concentrations rarely drop below 5.0 mg/L, the level below which potential problems could occur. During summer and fall, a seasonal influx of deep oceanic water that is low in DO leads to naturally occurring DO concentrations of less than 7.0 mg/L. Figure 4-7 shows the seasonal variation in DO concentrations for 2004 at both ambient and outfall sampling stations. There was no apparent difference in DO concentrations between outfall and ambient monitoring stations in 2004. DO concentrations below 5.0 mg/L were measured at an ambient station in central Elliott Bay (4.9 mg/L in September and 4.6 mg/L in October), an ambient station in the East Passage

(4.7 mg/L and 4.9 mg/L in October), and the South Treatment Plant outfall station (4.9 mg/L at two depths in October).

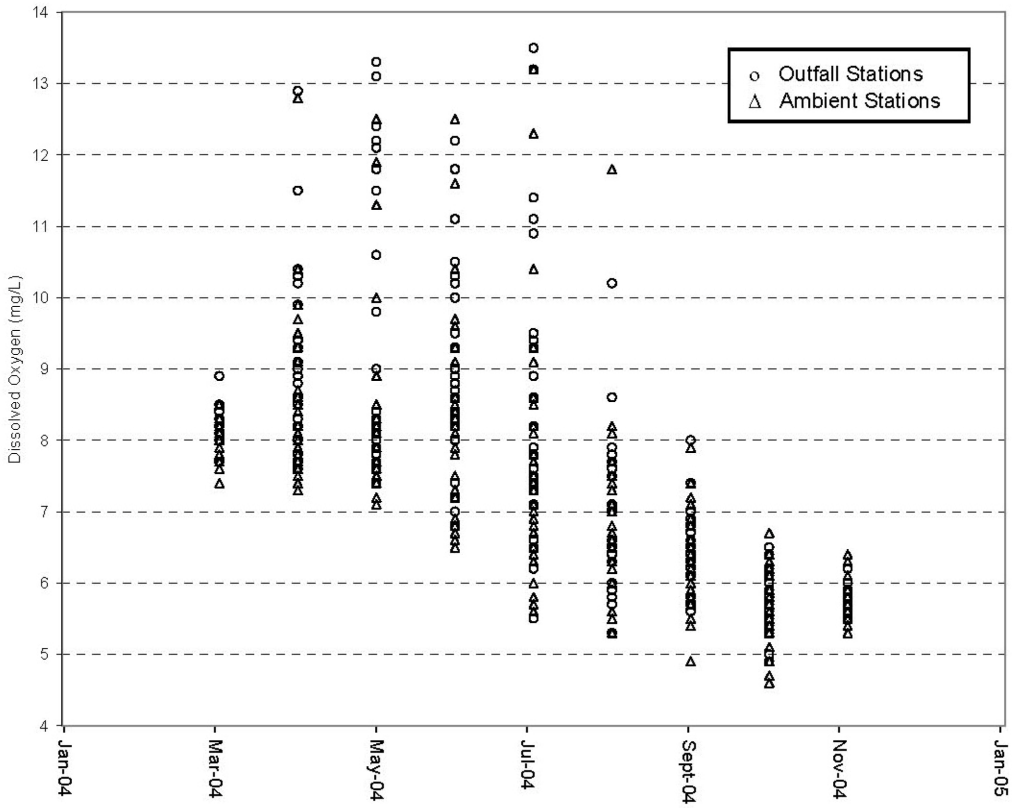

Figure 4-7. 2004 Dissolved Oxygen Concentrations in Puget Sound

Fecal Coliform Bacteria

Fecal coliform bacteria measurements indicate the amount of bacteria present but do not distinguish whether the bacteria are from a human or animal source.

With the exception of one station located in central Elliott Bay, all fecal coliform counts from offshore water columns, including those at treatment plant and combined sewer overflow (CSO) outfalls, met both the geometric mean and peak fecal coliform standards during 2004. The central Elliott Bay station met the geometric mean standard but failed the peak standard. The site has failed the peak standard in the past, mainly because of the freshwater influence of the Duwamish River during the wet season. Figure 4-8 and Figure 4-9 show the distribution of fecal coliform bacteria counts in offshore water column surface samples. Figure 4-8 shows that the majority of samples collected (71 percent) had no detectable bacteria and that only 3 percent had values over 10 colony forming units (CFU) per 100 mL. Figure 4-9 illustrates the distribution of counts for offshore water column surface samples between the outfall and ambient monitoring stations. Although the two highest bacteria counts were measured at the Denny Way CSO outfall where there is a strong freshwater influence on bacteria concentrations during wet weather, both bacteria standards were met at this station.

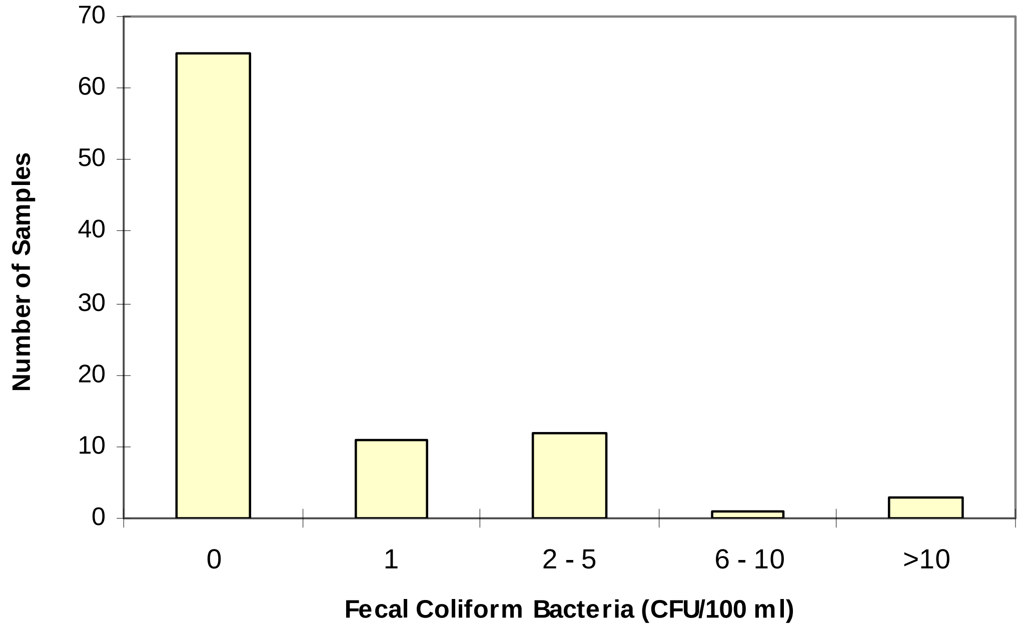

Figure 4-8. 2004 Distribution of Fecal Coliform Bacteria in Offshore Waters of Puget Sound

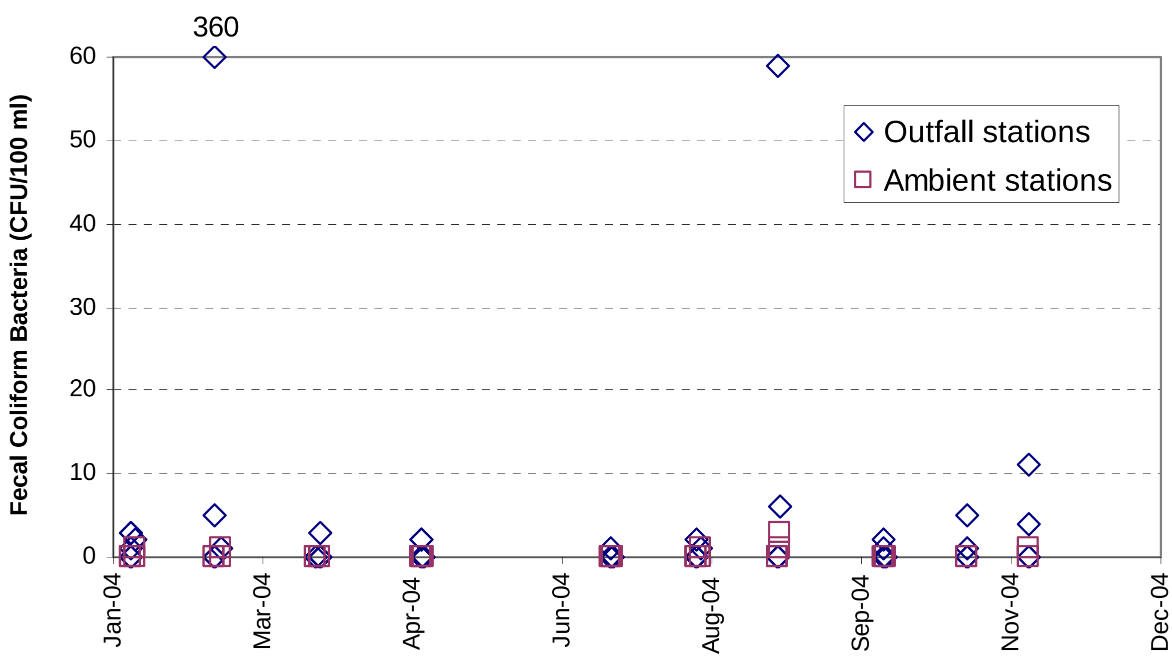

Figure 4-9. 2004 Fecal Coliform Bacteria Counts at Ambient and Offshore Sampling Stations in Puget Sound

Figure 4-10 shows the distribution of fecal coliform bacteria counts at King County marine beaches. Fecal coliform levels in water samples collected at beaches are influenced by a variety of factors, including proximity to freshwater sources, stormwater runoff, and waterfowl congregating in nearshore areas. As a result, a number of stations close to streams and other freshwater sources routinely exceed water quality criteria during high rainfall months. Stations that are in areas with restricted water movement also tend to exceed criteria more frequently than areas with ample tidal flushing. Beach stations that exceeded both the geometric mean and peak standards in 2004 included Shilshole Bay, inner Elliott Bay near Pier 48, Fauntleroy Cove, south Alki Point, and off of Vashon Island south of Dilworth. With the exception of the beach sampled south of Dilworth, which is a recent addition to the sampling program, the sites that failed both standards in 2004 also failed the standards in previous years. Almost all the stations are close to a freshwater source with the exception of the south Alki Point beach station. The reason for the bacterial exceedances at Alki are not clear. This beach is in the vicinity of the Alki CSO Treatment Plant outfall, but the outfall rarely discharges. The County will further investigate the reasons in 2005.

Several stations met the geometric mean standard, which incorporates multi-year sampling and is an indication of chronic bacteria exceedances, but failed the peak standard. In 2004, beaches at Carkeek Park (near Piper's Creek outflow), Golden Gardens, and Tramp Harbor fell into this category. These sites are near a freshwater source or in an embayment with weak tidal flushing.

Beach stations that met both standards in 2004 include Richmond Beach, West Point, Duwamish Head and Alki Beach, Lincoln Park, inner Elliott Bay near the Denny Way CSO outfall, Seahurst Park, Normandy Park, and Saltwater State Park.

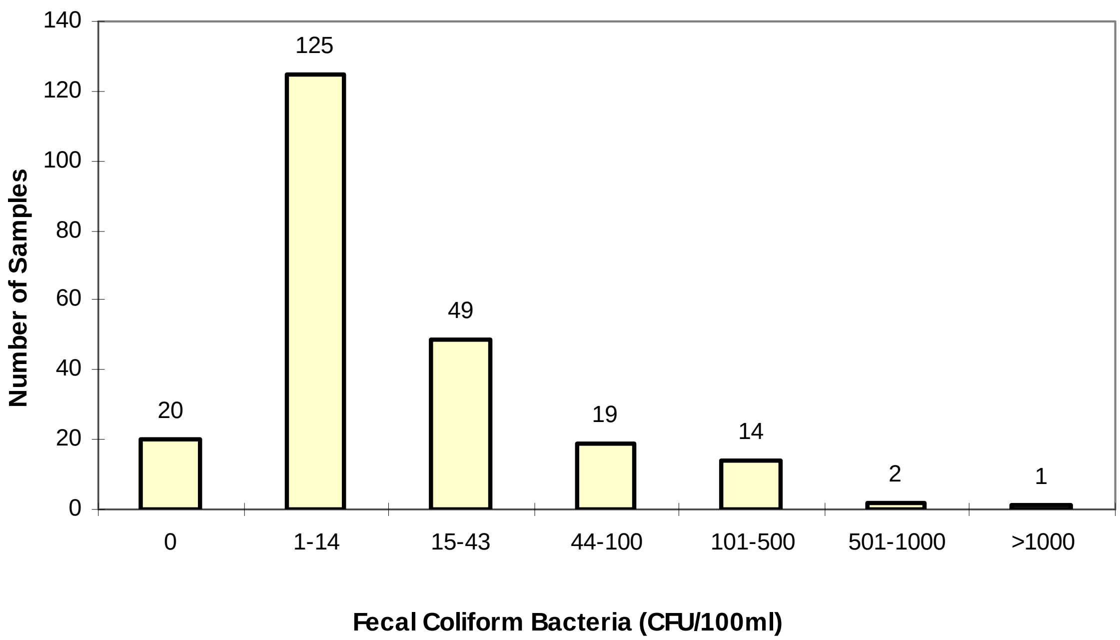

Figure 4-10. 2004 Distribution of Fecal Coliform Bacteria at King County Marine Beaches

Nutrients

Nutrients, including nitrogen (in the form of ammonia, nitrate, and nitrite), phosphorus, and silica are present in varying concentrations throughout the marine environment. Nitrate is the primary form of inorganic nitrogen in seawater. Nitrate concentrations generally increase with depth in the water column as the result of marine plant nitrogen uptake at the surface and bacterial remineralization of organic matter in deeper water. Maximum nitrate concentrations in Puget Sound tend to occur during the winter when phytoplankton growth is the lowest and freshwater flows are the highest. Nitrate concentrations at beach stations were similar to offshore stations and displayed the same seasonal trends. Nitrate concentrations and seasonal trends at outfall stations were similar to those observed at ambient stations.

All ammonia concentrations measured for offshore and beach stations over the last several years were well below the 1.6-mg/L chronic water quality criterion. The highest ammonia concentrations are consistently observed at the West Point and South Treatment Plant outfall stations, generally at the predicted effluent plume trapping depth and deepest depth for each site. Figure 4-11 shows ammonia profiles in 2004 for two ambient stations and the two main wastewater treatment plant outfall stations.

Phytoplankton Blooms

Phytoplankton blooms (as indicated by chlorophyll-*a* levels in water samples) in the Central Basin of Puget Sound exhibit seasonal trends, with major blooms generally occurring between April and July of each year. In 2004, blooms followed this same trend. Table 4-3 shows the location and timing of blooms throughout the Central Basin in 2004. The major blooms followed typical patterns for Puget Sound, occurring between April and August with a bloom in the South East Passage continuing into September.

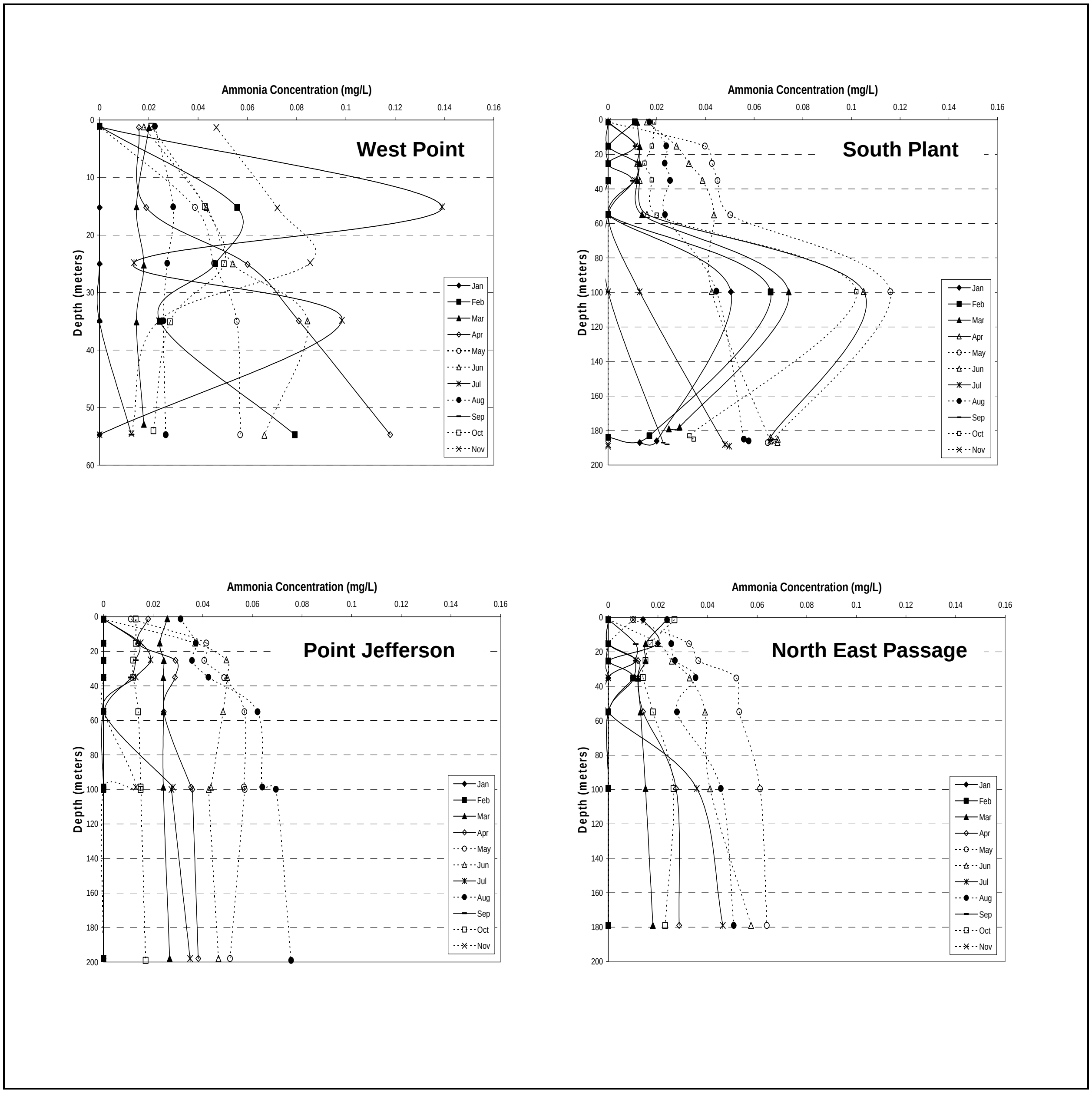

Figure 4-11. 2004 Ammonia Profiles for Ambient and Outfall Sites in Puget Sound

Table 4-3. Location and Timing of Phytoplankton Blooms in the Central Basin of Puget Sound in 2004, as Indicated by Chlorophyl-*a* Concentrations in µ/gL

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Point Wells					>10	>5	>10					
Jefferson Head				>5	>10	>10	>10					
Carkeek CSO Outfall				>5	>10	>10	>10					
West Point Outfall				>5	>10	>10	>10					
Denny CSO Outfall					>10		>10					
Elliott Bay				>5	>10	>5	>10					
South Plant Outfall				>10	>10	>10	>10	>5				
Alki Outfall				>10	>10	>10	>10	>10				
Dolphin Point				>10	>10	>10	>10					
Vashon Outfall				>10	>10	>10	>10					
South East Passage				>10	>10	>10	>10	>10	>5			

Sediment Quality

Treatment Plant Outfalls

Sediment monitoring at King County wastewater treatment plant outfalls has been completed until the next National Pollutant Discharge Elimination System (NPDES) permit cycle. Sediments were not collected from any of the outfall monitoring sites in 2004.

Ambient Locations

Sediment samples were collected from seven ambient monitoring sites in Puget Sound and Elliott Bay in Autumn 2004. These samples are currently undergoing chemical analysis; results of this monitoring will be published in early 2005.

Brightwater Marine Outfall Subsurface Sediment Characterization

Subsurface sediment were collected in 2003 from five borings along the nearshore alignment of the Brightwater marine outfall to determine the suitability of disposing trenching spoils at a Puget Sound Dredged Disposal Analysis (PSDDA) program open-water disposal site. Additional surface sediments were collected in 2004 to verify sediment quality after a fuel spill in January 2004 at the Point Wells bulk fuel terminal. Analytical results indicate that sediments are of high quality and suitable for disposal at a PSDDA facility; these results have been submitted to meet the requirements for obtaining the necessary PSDDA permit.

Denny Way CSO

Sediment samples were collected in late 2003 and early 2004 in the vicinity of the previous Denny Way CSO outfall and the two new outfalls. These sediments were collected as part of a long-term monitoring program for the Denny Way CSO improvement project, required under provisions of the Biological Opinion issued for the project under the Endangered Species Act. The monitoring was performed to evaluate post-construction changes to sediment quality and to establish a pre-operation baseline around the new outfalls. The monitoring did not detect any changes in sediment quality as the result of project construction. Baseline conditions show some contamination at the site of the old Denny Way CSO but also the presence of thriving benthic communities throughout the area. Results of sediment toxicity testing will be available in early 2005; complete monitoring results will be published in spring 2005.

Norfolk CSO

Sediment remediation at the Norfolk CSO site was completed in 1999. Sediment samples collected in April 2004 represented the fifth and final year of the post-remediation monitoring program. Results indicate that sediment quality at the four monitoring stations in the remediation area had changed slightly between 2003 and 2004. One chemical exceeded the Sediment Quality Standards (SQS) chemical criterion at one station. This is the first time that any chemical had exceeded the SQS criteria, and it is not clear what this exceedance means. Concentrations of all other detected chemicals were below SQS criteria. The sampling represents the completion of the required monitoring. Additional sampling may be done, however, to investigate the one exceedance.

Diagonal/Duwamish Remediation Dredging

The Diagonal/Duwamish Remediation Dredging project was completed in 2004. A program is under way to monitor the project and to determine if it is meeting its objectives. Sampling was conducted to address site conditions in the Duwamish River before, during, and after the dredging. The purpose of this sampling is to monitor for any spread of the contaminated sediments, to monitor for compliance with water quality standards during dredging, and to document final improvement over original conditions. These data also set the baseline for long-term monitoring to document cap stability and chemical recontamination of the cap surface. Water column samples taken during dredging showed that the chemicals of concern (mercury and PCBs) were found in low concentrations, below any existing water quality standards. Results of sediment sampling indicated that some contamination was spread offsite during the capping. A follow-up action is planned for early 2005 to address the problem.

Chapter 5

Developing Issues and Needs

In the coming year, King County will face some unique challenges and some new opportunities for change. Creating a balance in water needs and water resources for fish and people continues to be an ongoing focus.

Endangered Species Act

Since 2000, King County has been engaged in several efforts related to the Endangered Species Act (ESA), including preparation of a proposal concerning compliance with the ESA 4(d) rule, review of its practices for compliance with the chinook 4(d) rule, and preparation of a Habitat Conservation Plan.

In 2000, National Oceanic and Atmospheric Administration (NOAA) Fisheries (formerly National Marine Fisheries Service) adopted a draft protective rule under section 4(d) of ESA prohibiting the “take” of salmon and steelhead species previously listed as threatened under ESA. Following the adoption of the rule, King County began a review of its activities to determine how the Wastewater Treatment Division (WTD) should modify its practices to stay within the parameters set out in the 4(d) rule. Affected areas of our business include construction practices and uses of property near water bodies.

For treatment plant discharges, NOAA stated in the 4(d) rule that it would work with permitting authorities (Washington State Department of Ecology) to ensure that permitted discharges do not violate the ESA. NOAA Fisheries, the U.S. Fish and Wildlife Service (USFWS), and the U.S. Environmental Protection Agency have signed a Memorandum of Agreement to work together on integrating the Clean Water Act standards and the ESA requirements. Both NOAA Fisheries and USFWS have the opportunity to review NPDES permits.

King County, therefore, is concentrating its efforts on working with NOAA Fisheries and the USFWS to develop a Habitat Conservation Plan (HCP) to gain certainty regarding what must be done to develop projects that comply with the ESA. In 2003, the County participated in three public meetings hosted by the federal Services as part of the National Environmental Policy Act (NEPA) requirements for federal actions. In addition, regular negotiation sessions were held with the Services and the Tribes and an internal draft HCP was compiled for review in late 2003. It is anticipated that a draft HCP and NEPA environmental impact statement will be completed in 2005.

Watershed Resource Inventory Area (WRIA) Planning

Watershed planning activities under precedent-setting interlocal agreements (ILAs) continued in 2004—the fourth year of these activities. ILAs involve cost sharing by more than 45 jurisdictions in support of the salmon conservation planning effort as well as a new governance-management construct. As a result of the success and accomplishments of the first four years, all jurisdictions have agreed to continue funding for 2005 work.

In both WRIAs 08 and 09, Near-Term Action Agendas (NTAAs) based on the scientific information gathered in the Reconnaissance Assessments provide voluntary opportunities for the short term. In 2003 and continuing through 2004, the planning effort turned to development of Salmon Conservation Plans (also termed Habitat Plans). These plans describe long-term habitat conservation and recovery actions in WRIAs 08 and 09 that take an ecological approach but concentrate on the needs of the ESA-listed species of chinook salmon and bull trout.

Of equal importance, work on the Strategic Assessments was completed in 2004. The Strategic Assessments provide the technical foundation for the Salmon Conservation Plans as well as baseline information needed for adaptive management. The Strategic Assessments result in a more complete understanding of problems and opportunities in the watershed that are related to salmon and salmon habitat conservation and recovery, with a focus on ESA-listed species.

A public review draft Salmon Conservation Plan was released for WRIA 08 in 2004. The ILA service provider staff is reading a Steering Committee[1] draft to be forwarded to the WRIA 08 Forum in early 2005 for review. Under the ILA, the Forum[2] will have 90 days to approve the plan for referral to the local jurisdictions for ratification or to remand the plan to the Steering Committee for additional work and refinements. Work on the WRIA 09 Salmon Conservation Plan continued in 2004; the plan will be released for public review in early 2005.

In 2005, the WRIA Forums will address Salmon Conservation Plan implementation, the governance-management construct, if any, that they will develop, and the funding mechanisms necessary to implement the plans. In addition, negotiations with NOAA Fisheries and USFWS with regard to assurances will occur as the WRIA plans are rolled up into a regional recovery plan under the aegis of Shared Strategy for Puget Sound, a regional recovery organization.

Many of the questions that need to be answered in regard to the WRIAs are identical to those that WTD must address in various projects. While the scientific needs of the WRIAs have been greater (for instance, in terms of geographic extent) than the specific needs of WTD, supporting the success of WRIA planning will ensure a sound framework for reasonable ESA requirements from the federal government for the Regional Wastewater Services Plan.

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[1] The Steering Committee is composed of citizens, scientists, business representatives, environmentalists, elected officials, and state and federal agencies.

[2] The Forum is composed of elected officials from the local governments funding this process.

Total Maximum Daily Loads

Defined by the U.S. Environmental Protection Agency (EPA), a total maximum daily load (TMDL) is a calculation of the maximum amount of a pollutant that a water body can receive and still meet Water Quality Standards. When a water body fails to meet Water Quality Standards, the Clean Water Act requires that a TMDL and a pollutant allocation be done for that water body. EPA or the Washington State Department of Ecology (Ecology) makes allocations of that pollutant to its sources, such as stormwater runoff and municipal or industrial discharges.

Any water bodies consistently identified by the state as not meeting Water Quality Standards must have a TMDL prepared. New federal rules for performing TMDL analysis were scheduled to go into effect in October 2001, but have since been rescinded. EPA was expected to propose new rules in 2003, but this did not occur. Under the current federal rules, many King County water bodies already listed by the state as having impaired water quality must have TMDLs prepared as soon as possible. As a result, King County will need to give increased attention to water quality data collection and modeling so that TMDL calculations done by Ecology will be based on good science and will be as accurate and complete as possible.

In 2001, King County completed a joint project with the Ecology to begin work on TMDLs for certain county water bodies. In particular, a model sediment TMDL was developed and approved by EPA in its first application to a site in Bellingham Bay. This model will eventually be applied to the Lower Duwamish Waterway and other County remediation sites.

On January 15, 2004, Ecology released its proposed updated list of impaired water bodies as a part of a more comprehensive reporting on all the states waters. This new reporting will also list water bodies where Ecology has concern that waters may be impaired but lacks the data to confirm this possibility, and water bodies that have no water quality data. This new reporting system may increase pressure on the state and local governments to undertake sampling programs that will more accurately assess local waters. The information required to site, construct, or expand facilities will also likely increase. In October 2004, Ecology released a second draft of this list and solicited comments through December 2004. It is expecting to finalize the list in 2005.

Endocrine Disrupting Chemicals

Chemicals that mimic hormones in animals (fish, birds, people) may sometimes result in changes in how an animal's endocrine or reproductive systems work. These chemicals have been called suspected endocrine disrupting chemicals (EDCs) or endocrine disrupters. Some of these chemicals may be found in stormwater and treated municipal wastewater. In 2004, King County staff attended technical meetings to learn more about these chemicals and their potential effects. The County also added a page to its Web site that gives general information on the topic.[3]

[3] http://dnr.metrokc.gov/WTD/community/edc/index.htm

To add to the understanding of EDCs, King County also undertook some initial screening level sampling of its surface waters during 2003 and 2004 to determine if there are measurable suspected EDCs present. A report on the results of this sampling is expected in 2005. The County was also one of 50 participants in an EPA study of effluents throughout the United States and has offered to participate in other national studies on EDCs. The County will continue to follow this issue.

Sediment Contaminant Source Control

Source control of upland properties is needed to ensure that sediment cleanup sites are not recontaminated. In the Lower Duwamish Waterway and Harbor Island/East Waterway Superfund sites, the size of the industrial area makes source control particularly challenging. Effective source control is very important to the County's combined sewer overflow (CSO) control program. If it is not successful, imposed solutions may include acceleration of project schedules or implementation of higher levels of control than is currently planned—either could have significant consequences for the Regional Wastewater Services Plan (RWSP) capital program. To increase source control effectiveness, a new intensive and integrated cross-agency source control effort is being implemented in the Diagonal/Duwamish basin. Four separate programs are now being coordinated to make it easier for businesses to identify and control pollutant sources. In the next few years, the County will determine if this approach has been successful. For more information on this program, see the "Industrial Waste Program" section in Chapter 2 of this report.

Appendix A

Glossary

Algae: Plants that grow in surface w7897aters in relative proportion to the amount of light, nutrients, and attachment sites available. Algae are food for fish and other aquatic organisms.

Benthos: The communities of aquatic life that dwell in or on the bottom of sediments of a water body.

Biochemical Oxygen Demand (BOD): The amount of dissolved oxygen required to meet the metabolic needs of microorganisms in water, wastewater and effluents.

Biosolids: The organic solids separated from raw wastewater or produced by the wastewater treatment process. Biosolids contain large amounts of organic matter.

Chlorophyll: The green pigment in plants that allows them to create energy from light (photosynthesis). By measuring chlorophyll, one indirectly measures the amount of photosynthesizing plants, or algae, in the water column. Chlorophyll- α is a measure of the portion of the pigment that is still actively photosynthesizing at the time of sampling.

Combined Sewer Overflow (CSO): An overflow of combined wastewater and stormwater. CSOs occur when stormwater from heavy rains exceed the capacity of the wastewater collection system.

Dissolved Oxygen (DO): The oxygen that is freely available in water. Certain amounts are necessary for life processes of aquatic animals. The oxygen is supplied by the photosynthesis of plants and by aeration. Oxygen is consumed by animals, plants, and bacteria that decompose dead organic matter and some chemicals.

Effluent: Treated or untreated water or wastewater flowing out of a treatment facility, sewer, or industrial outfall. Generally refers to discharges into surface waters.

Eutrophic: The trophic state of lakes with high concentrations of nutrients and algae and with low transparency or clarity.

Eutrophication: The natural physical, chemical, and biological changes that take place as nutrients, organic matter, and sediment are added to a lake. When accelerated by human-caused influences, this process is called cultural eutrophication.

Fecal Coliforms: The intestinal bacteria from warm-blooded animals that are routinely used as an indicator of wastewater pollution in water and as an indicator of the human health risk.

Influent: Water, wastewater, or other liquid flowing into a treatment facility.

Mesotrophic: The trophic state of lakes that have moderate concentrations of nutrients and algae between those found in eutrophic and oligotrophic lakes.

National Pollutant Discharge Elimination System (NPDES): NPDES comes from Section 402 of the Clean Water Act. It prohibits the discharge of pollutants into navigable waters of the United States unless a special permit is issued by the U.S. Environmental Protection Agency, a state, or a tribal government.

Nonpoint Source: An input of pollutants into a water body from unidentifiable sources, such as agriculture, the atmosphere, and stormwater or groundwater runoff.

Nutrient: An inorganic or organic compound essential for growth of organisms.

Oligotrophic: The trophic state of lakes with low concentrations of nutrients and algae and high transparency.

Phosphorus: The primary nutrient of concern in freshwater systems as it can cause nuisance algal blooms if present in excess amounts.

Phytoplankton: Marine plants, mostly small to microscopic in size, that are suspended in the water column and drift with the currents.

Point Source: An input of pollutants into a water body from discrete sources, such as municipal or industrial outfalls.

Primary Contact Recreation: Activities where a person would have direct contact with water to the point of complete submergence, including but not limited to skin diving, swimming, and water skiing.

Productivity: The rate at which organic matter is formed that is averaged over a defined period of time.

mg/L: Milligrams per liter. Used in describing the amount of a substance in a given volume of liquid. Equal to parts per million (ppm).

Secchi Depth: The measure of lake water clarity used primarily as an indicator of algal abundance. Clarity is affected by algae, soil particles, and other materials suspended in the water.

Secondary Contact Recreation: Activities where a person's contact with water would be limited (such as wading or fishing) to the extent that bacterial infections of the eyes, ears, respiratory system, digestive system, or urogenital areas would normally be avoided.

Thermal stratification: Layering of lake water caused by differences in water density. During summer months, deep lakes divide into three layers: the epilimnion (uppermost, warmest layer), hypolimnion (lower, cooler layer) and metalimnion (middle layer).

Trophic State Index (TSI): One of the most common lake indices used to characterize water quality . Developed by Robert Carlson in 1977. This index provides a standard measure to compare lake quality on a scale of 0 to 100. Each major division (10, 20, 30, etc.) represents a doubling of algal biomass and is related to nutrient levels and transparency.

Water Column: The area of water contained between the surface and the bottom of a water body.

Appendix B

Web Sites

Water Monitoring Programs

King County Environmental Laboratory
http://dnr.metrokc.gov/wlr/envlab/index.htm

King County Lakes Monitoring Program
http://dnr.metrokc.gov/wlr/waterres/lakes/

King County Beach Monitoring Program
http://dnr.metrokc.gov/wlr/waterres/lakes/bacteria.htm

King County Streams Monitoring Program
http://dnr.metrokc.gov/wlr/waterres/streams/creekindex.htm
http://dnr.metrokc.gov/wlr/waterres/Bugs/index.htm

King County Marine Monitoring Program
http://dnr.metrokc.gov/wlr/waterres/marine/marine.htm

Beach Environmental Assessment Communication & Health Program (BEACH) (marine beaches)
http://www.doh.wa.gov/ehp/ts/WaterRec/beach/default.htm

Water Quality Management Programs

Wastewater Treatment Division
http://dnr.metrokc.gov/wtd/

King County's CSO Control Program
http://dnr.metrokc.gov/wtd/cso/index.htm
http://dnr.metrokc.gov/wlr/waterres/wqa/wqpage.htm
http://dnr.metrokc.gov/wtd/dennyway/
http://dnr.metrokc.gov/wtd/henderson-cso/

City of Seattle's CSO Control Program
http://www.ci.seattle.wa.us/util/CSOPlan/default.htm

King County Hazardous Waste Program
http://www.metrokc.gov/hazwaste/house/

King County Industrial Waste Program
http://dnr.metrokc.gov/wlr/indwaste/index.htm

King County Integrated Pesticide Management Program
http://www.metrokc.gov/hazwaste/ipm/

King County Sediment Management Program
http://dnr.metrokc.gov/wlr/waterres/norfolk/norfolk.htm

King County Biosolids Program
http://dnr.metrokc.gov/WTD/biosolids/index.htm

King County Water Reuse Program
http://dnr.metrokc.gov/wtd/reuse/index.htm

State of Waters

Cedar watershed
http://dnr.metrokc.gov/wlr/watersheds/cedar-lkwa.htm

Lake Washington
http://dnr.metrokc.gov/wlr/waterres/lakes/biolake.htm
http://dnr.metrokc.gov/wlr/waterres/lakes/Wash.htm

Sammamish basin
http://dnr.metrokc.gov/wlr/watersheds/samm.htm
http://dnr.metrokc.gov/wlr/waterres/lakes/SAMM.htm

Lake Union
http://dnr.metrokc.gov/wlr/waterres/lakes/UNION.htm

Green watershed
http://dnr.metrokc.gov/wlr/watersheds/green.htm

Puget Sound watershed
http://dnr.metrokc.gov/wlr/watersheds/puget.htm

King County salmon recovery activities
http://dnr.metrokc.gov/topics/salmon/SALtopic.htm
http://dnr.metrokc.gov/Wrias/9/index.htm
http://dnr.metrokc.gov/Wrias/8/index.htm